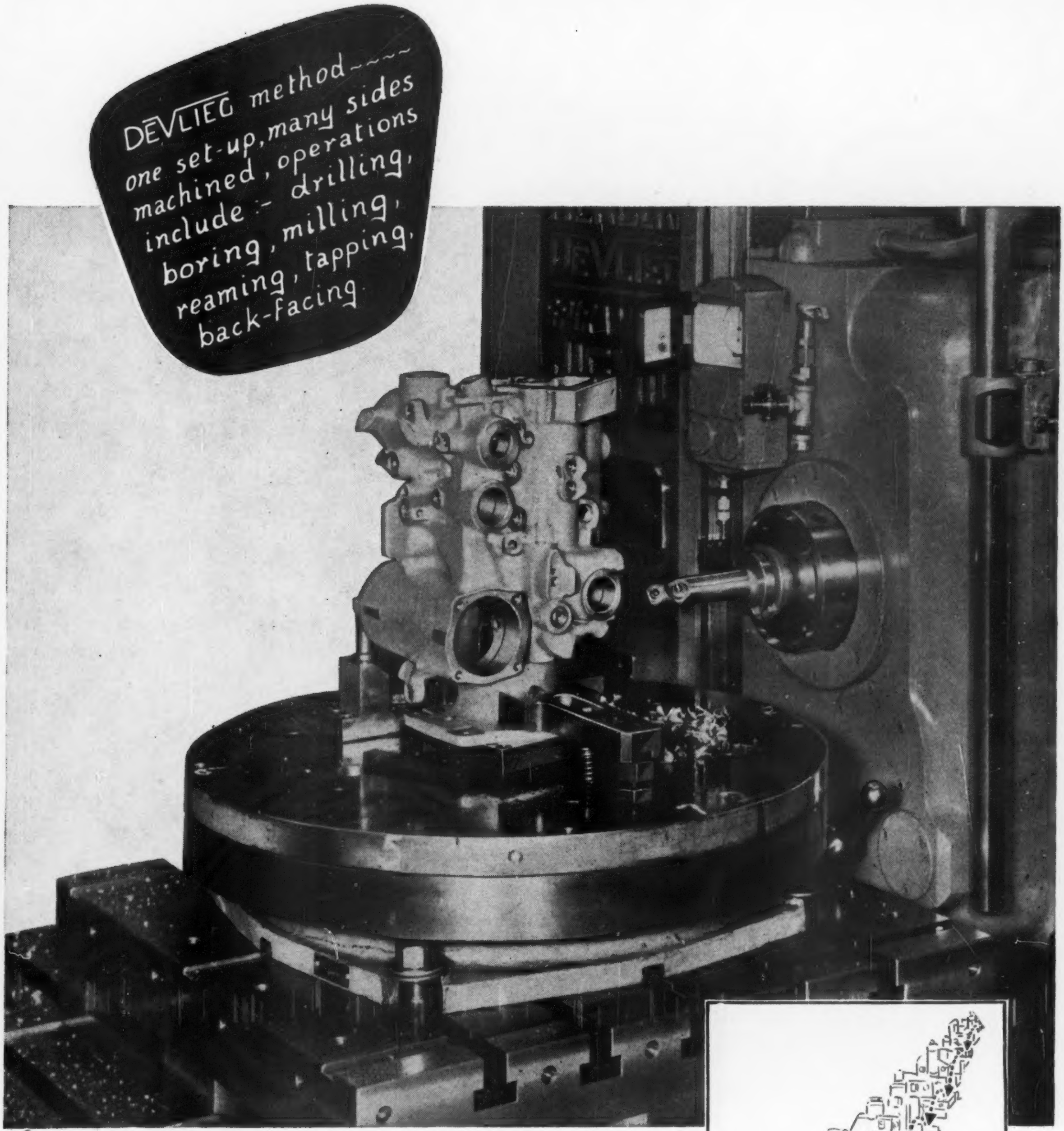
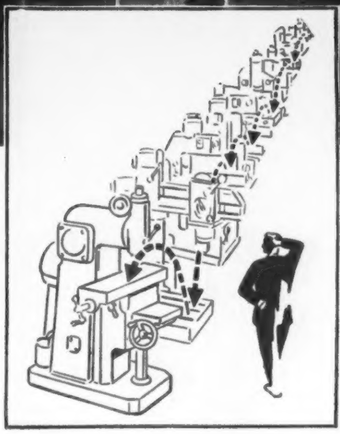
AUTOMOBILE ENGINEER

DESIGN · PRODUCTION · MATERIALS

Vol. 47 No. 9 SEPTEMBER 1957 PRICE: 3s. 6d.



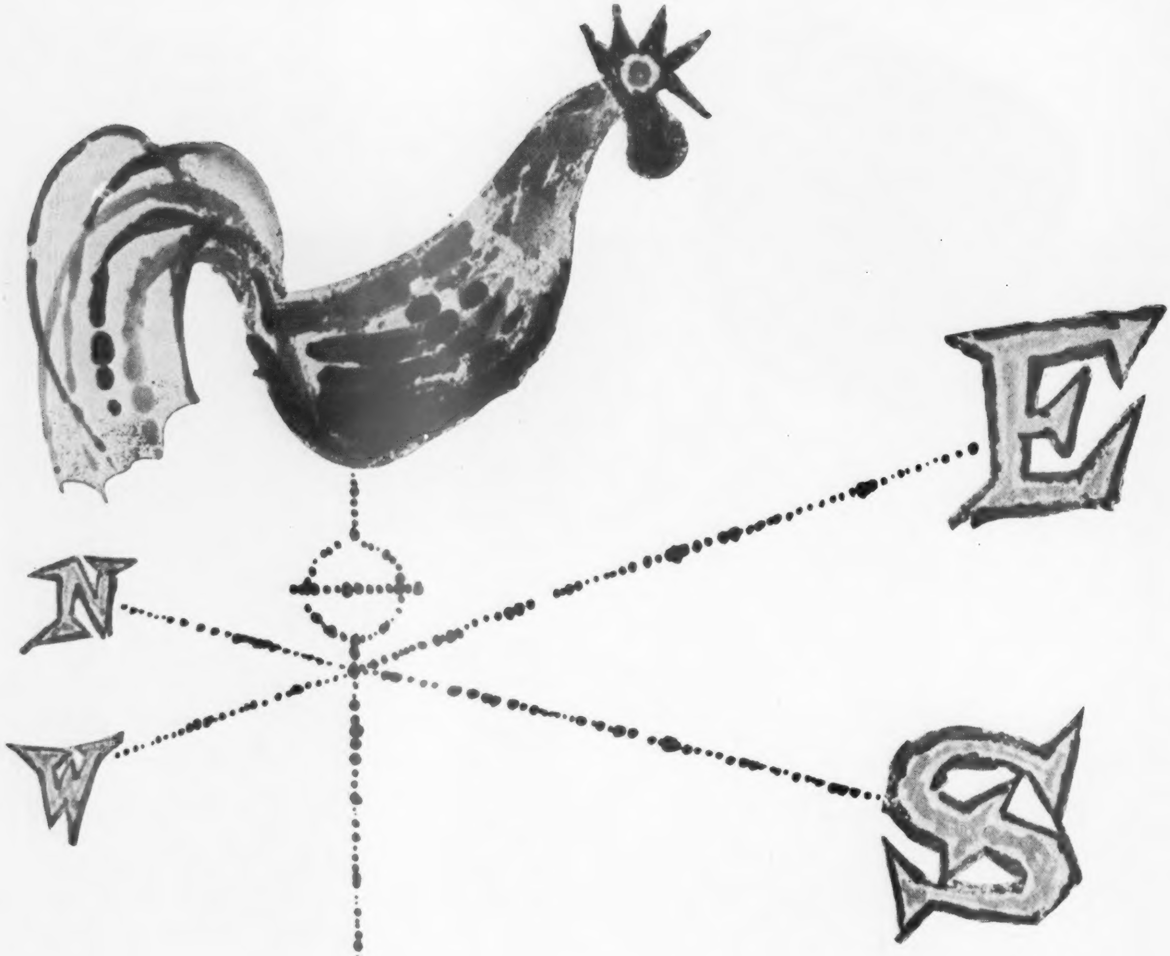


An open-sided machine.
Jigless boring method for the toolroom or for production.
Constant horse-power at all speeds.
Pre-selection of spindle speeds.
Automatic depth control.
Power-operated tool lock.
Indexing table permits precise in-line boring using short bars.
Precise co-ordinate automatic location of work and spindle by centralised push-button control.
Capable of milling up to the full horse-power of the spindle motor.

The smallest of the range of DeVlieg Jigmils, the 2B/36, *is now being British built in the new specially-equipped extensions to our Lutterworth Works. Its capacity is* 24″ *(vertical),* 36″ *(horizontal) and has a* $2\frac{1}{2}$″ *diameter spindle*

ALFRED HERBERT LTD. *Factored Division, Red Lane Works, Coventry*

AD.314



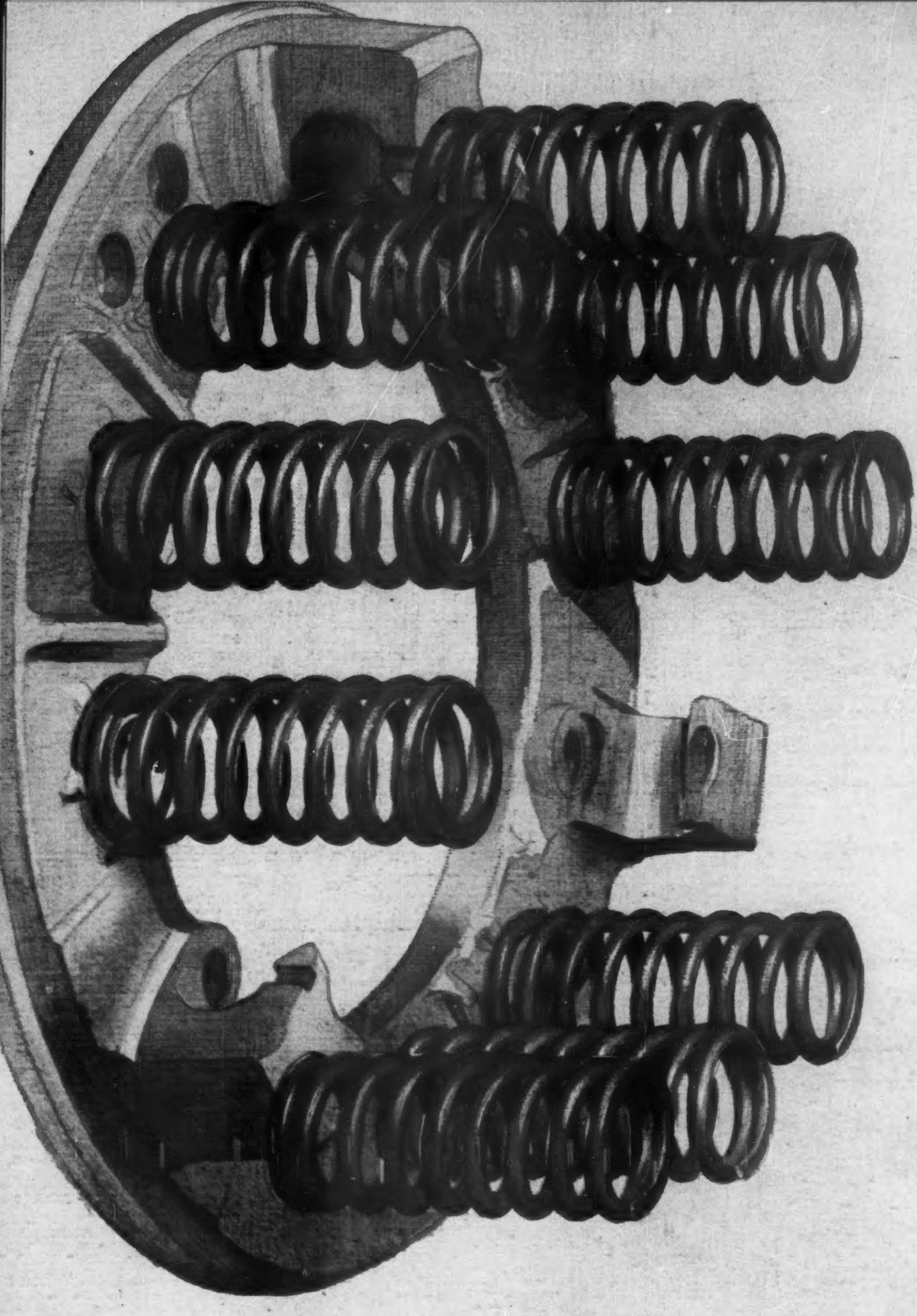
PETROL AGENCY DERV

SHELL DERV

Shell meets the demand for DERV all over Britain

To give the best possible service to the increasing number of diesel powered transport vehicles now in operation, Shell have established a nation-wide network of agencies selling SHELL DERV. Wherever you send a diesel vehicle you can be sure that a SHELL DERV station will be close at hand. Your drivers can pay cash for SHELL DERV or by showing a Shell "Authority Card" they can refuel by a system of pre-arranged credit at any Shell agency.

YOU CAN BE SURE OF SHELL DERV



Features that have built success

When the loads to be transmitted are such that heavy spring pressures are needed, the Borg & Beck design permits them to be spread uniformly over the pressure plate, minimizing localized stresses and consequent distortion.

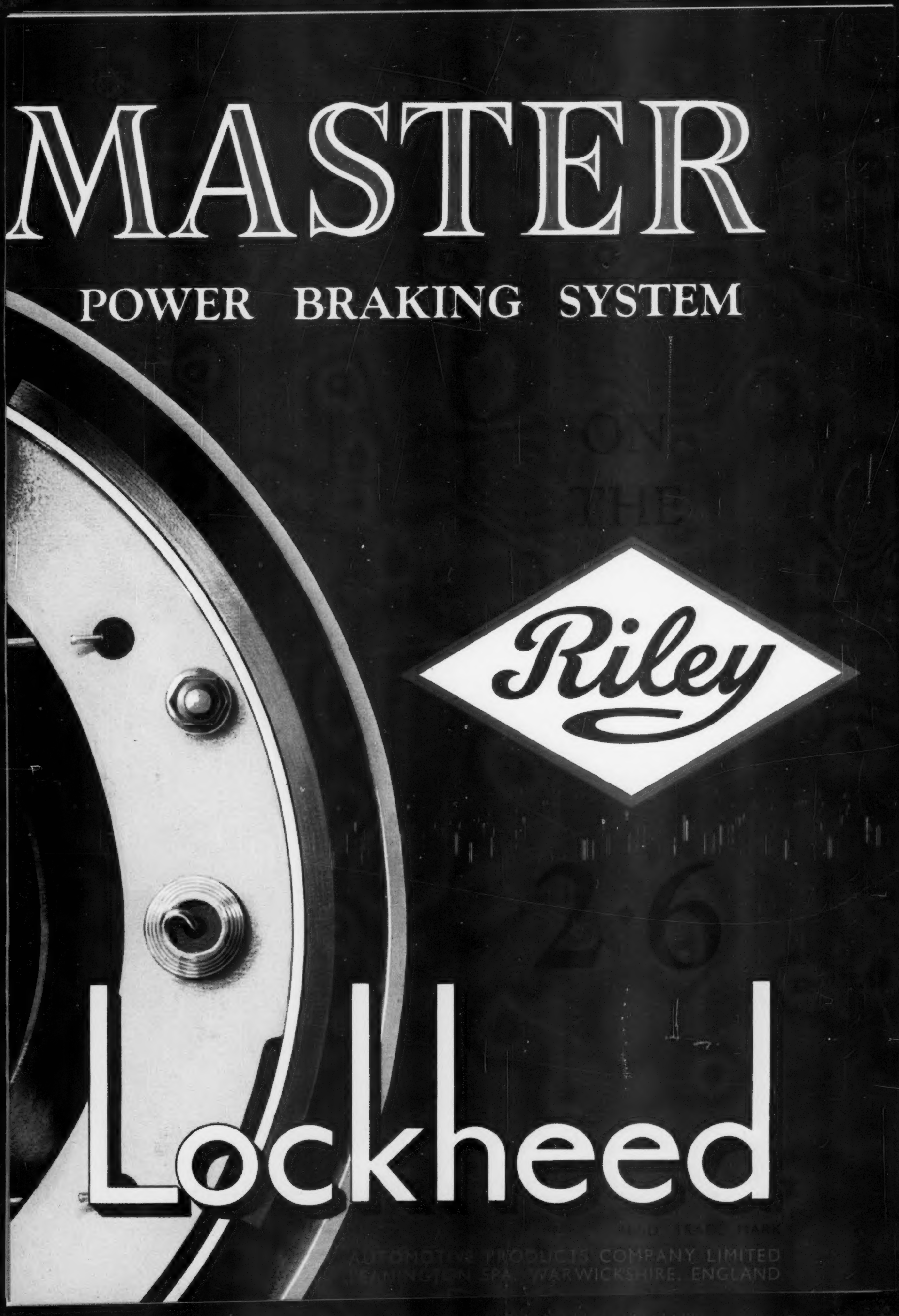
By the choice of groups of springs of different strengths—identified by colour—or even by the omission of some in lightly loaded clutches—a great range of operative spring pressures is attainable from standard clutch components.

BORG & BECK

REGISTERED TRADE MARK: BORG & BECK

BORG & BECK COMPANY LIMITED, LEAMINGTON SPA, WARWICKSHIRE, ENGLAND


BRAKE



MASTER
POWER BRAKING SYSTEM
ON THE
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2 6
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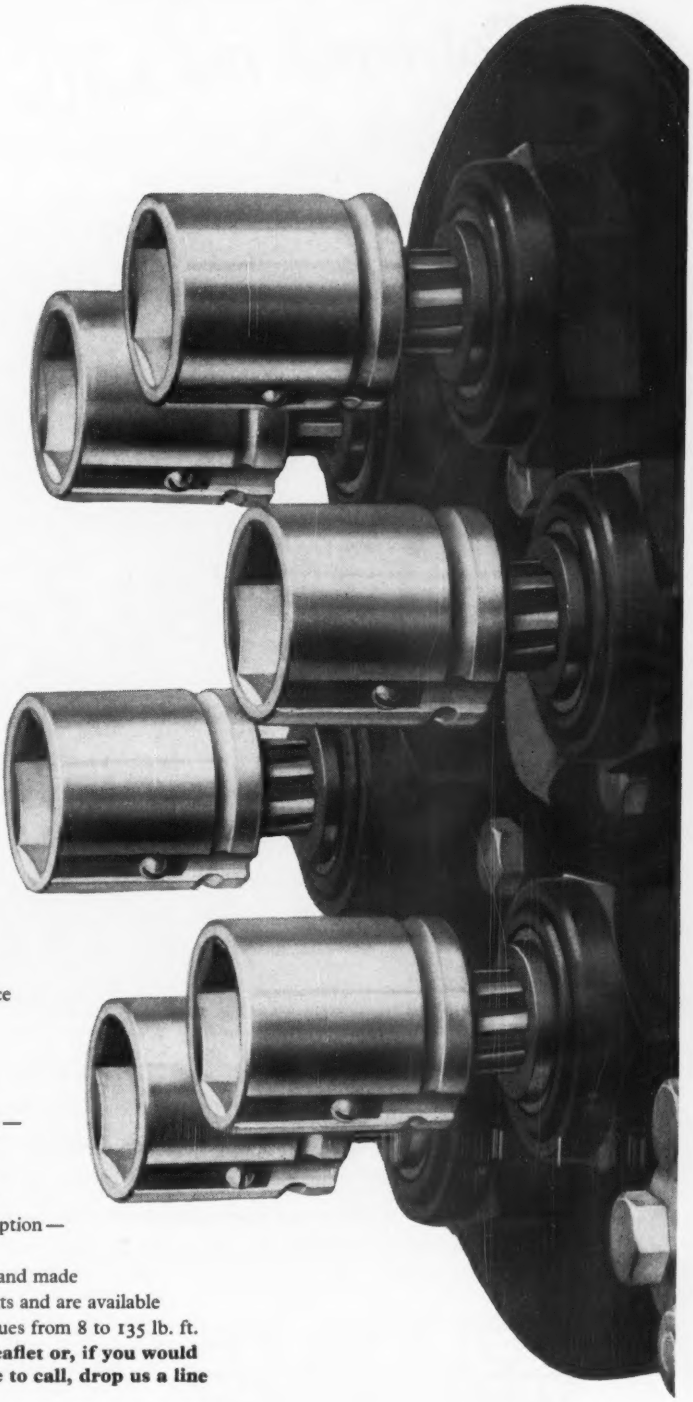
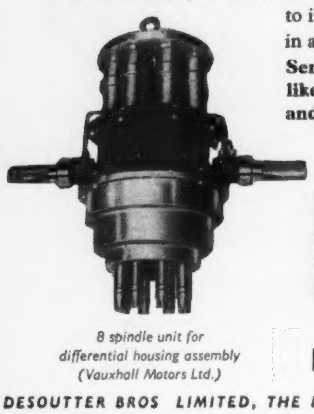
AUTOMOTIVE PRODUCTS COMPANY LIMITED
LEAMINGTON SPA, WARWICKSHIRE, ENGLAND

new *Silent* **MULTIPLE**
nut runner units
produce torques of

135 lb.ft.



For years we've been making pneumatic multiple nut runner units with motors producing torques of up to 50 lb. ft. The *new* Desoutter motors produce torques of up to 135 lb. ft.—without consuming any extra air.
What's the big secret? A motor with a 2-speed gearbox. This motor works at fast speeds for running down nuts, at slow speeds for tightening up—and the change of speed is automatic.
Compared with any other multiple units these new Desoutter tools give *three* times the performance—or the same performance at one third the air consumption—with even greater uniformity of torque.
Desoutter Multiple Nut Runner Units are designed and made to individual requirements and are available in a wide range, for torques from 8 to 135 lb. ft.
Send for descriptive leaflet or, if you would like our representative to call, drop us a line and we'll arrange it.



8 spindle unit for differential housing assembly (Vauxhall Motors Ltd.)

Desoutter 2-speed

multiple nut runner units

DESOUTTER BROS LIMITED, THE HYDE, LONDON, N.W.9. TEL: COLINDALE 6346 (5 LINES). GRAMS: DESPNUCO, HYDE, LONDON
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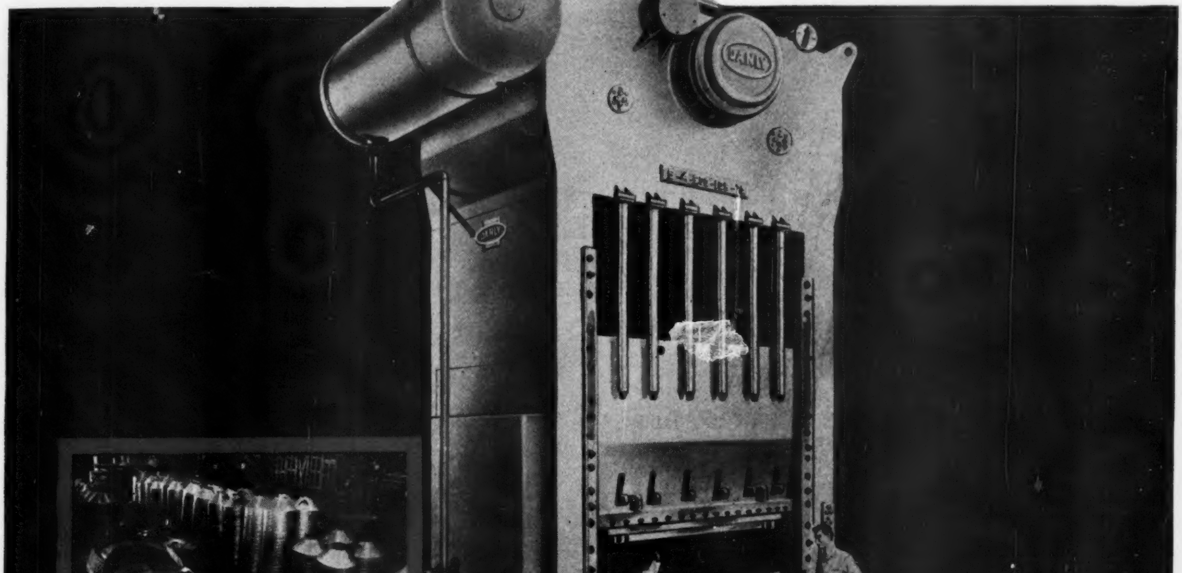

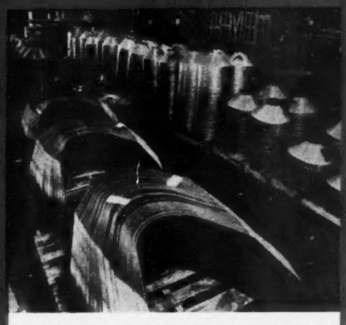

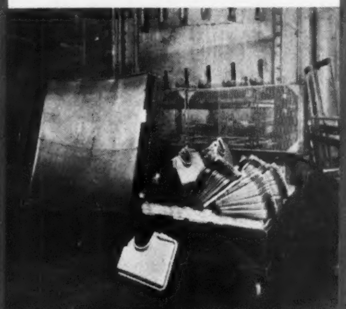

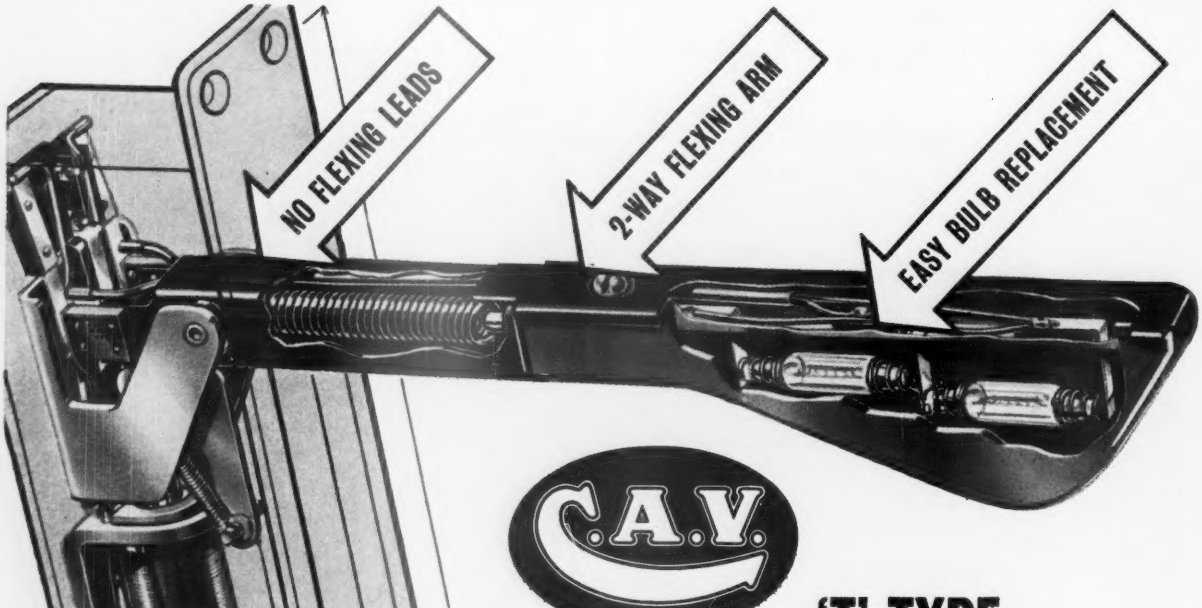

'T' TYPE DIRECTION INDICATORS

Designed specifically for transport vehicles

These indicators are of most robust construction, having been designed and built to give long and trouble-free service on public transport and commercial vehicles. The unique flexing arm prevents accidental damage, whilst a spring lock permits the arm to be raised for maintenance or bulb replacement. Each unit is designed for flush fitting and is weather-proofed. The arm is illuminated by twin bulbs, wired in parallel, and spring-mounted to ensure long life. There are no flexible leads between mechanism and indicator arm, thus eliminating a common cause of failure. A special indicator switch, type 204, has been developed for use with these indicators. This is self-cancelling, with incorporated indicator light, and the delay may be preset between 5 and 20 seconds. An over-riding control permits immediate cancellation.

Self-cancelling switch, with warning light

C.A.V.

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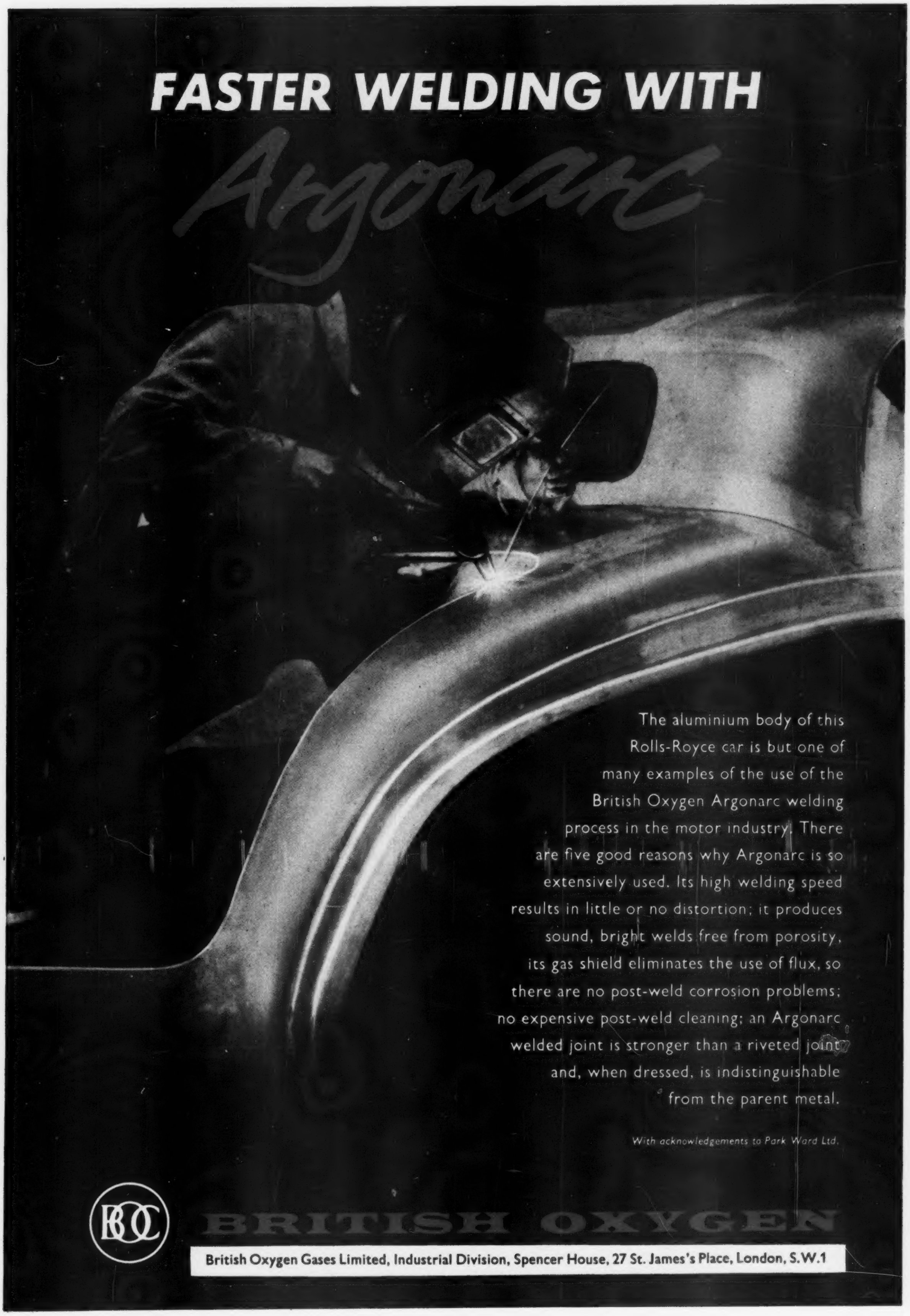
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Argonarc
The aluminium body of this Rolls-Royce car is but one of many examples of the use of the British Oxygen Argonarc welding process in the motor industry. There are five good reasons why Argonarc is so extensively used. Its high welding speed results in little or no distortion; it produces sound, bright welds free from porosity, its gas shield eliminates the use of flux, so there are no post-weld corrosion problems; no expensive post-weld cleaning; an Argonarc welded joint is stronger than a riveted joint and, when dressed, is indistinguishable from the parent metal.
With acknowledgements to Park Ward Ltd.
BOC
BRITISH OXYGEN
British Oxygen Gases Limited, Industrial Division, Spencer House, 27 St. James's Place, London, S.W.1

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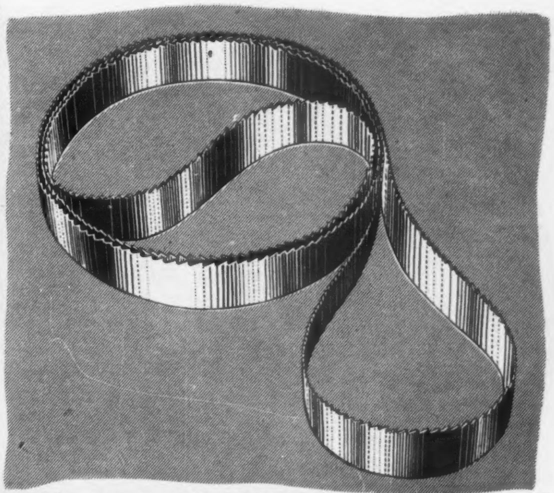

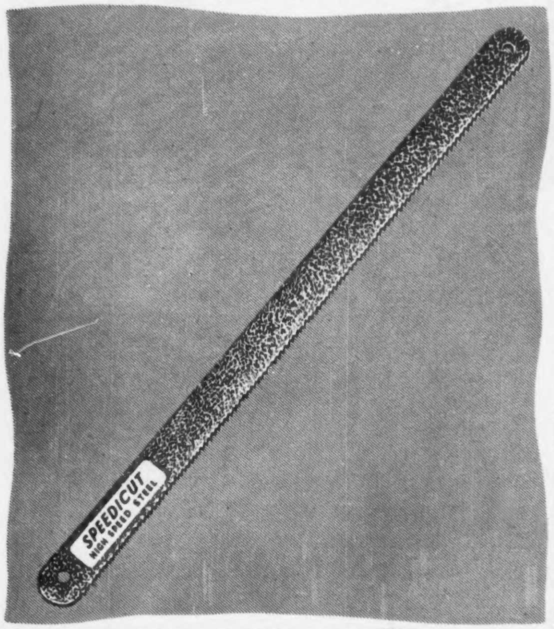

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and

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Made in Britain's

Largest tool factory

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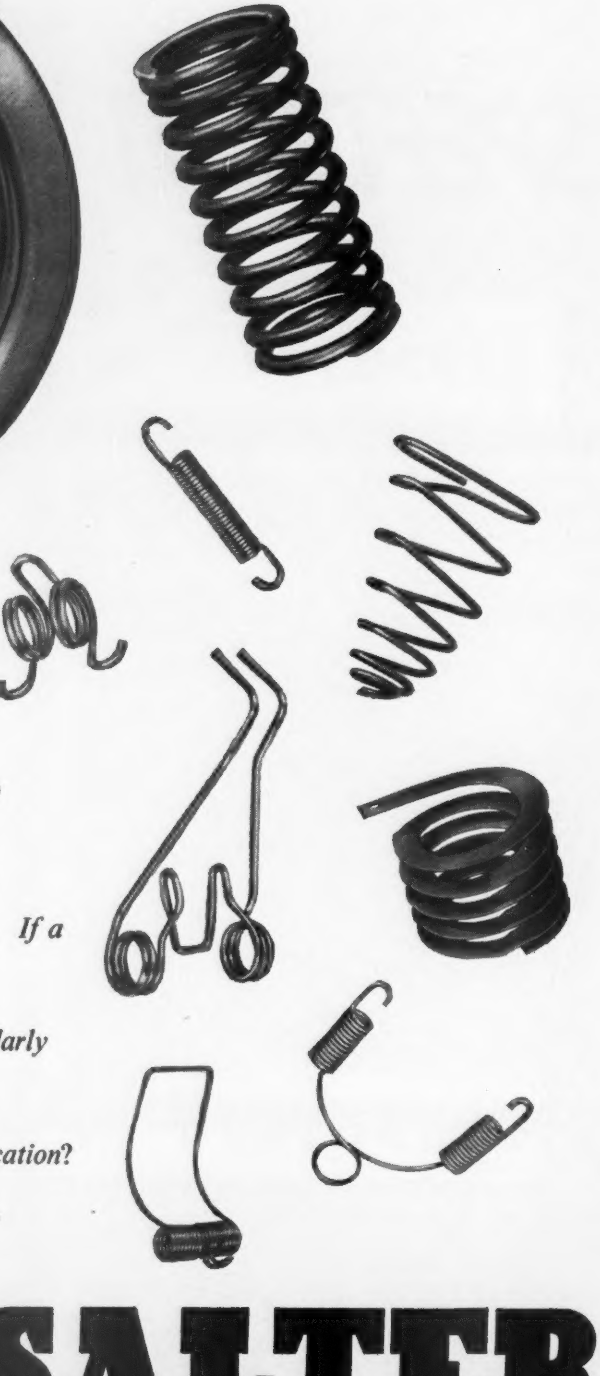
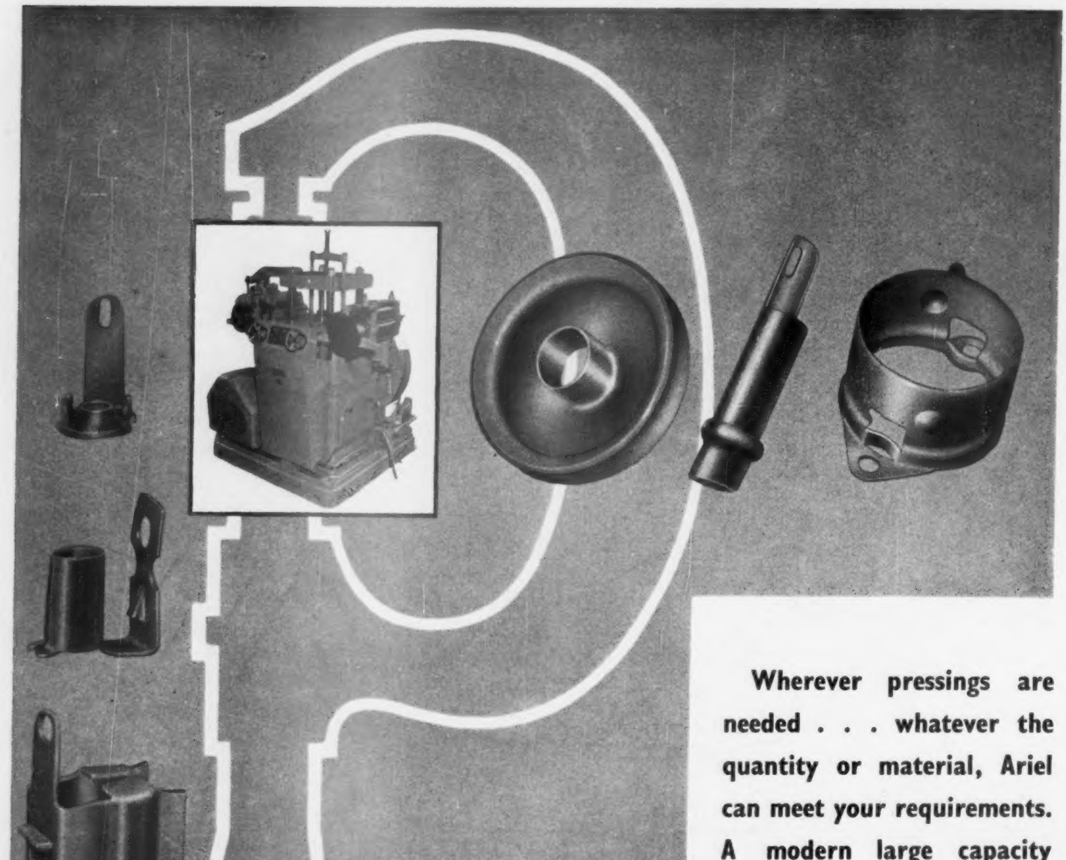


MASS PRODUCED TO FINE LIMITS



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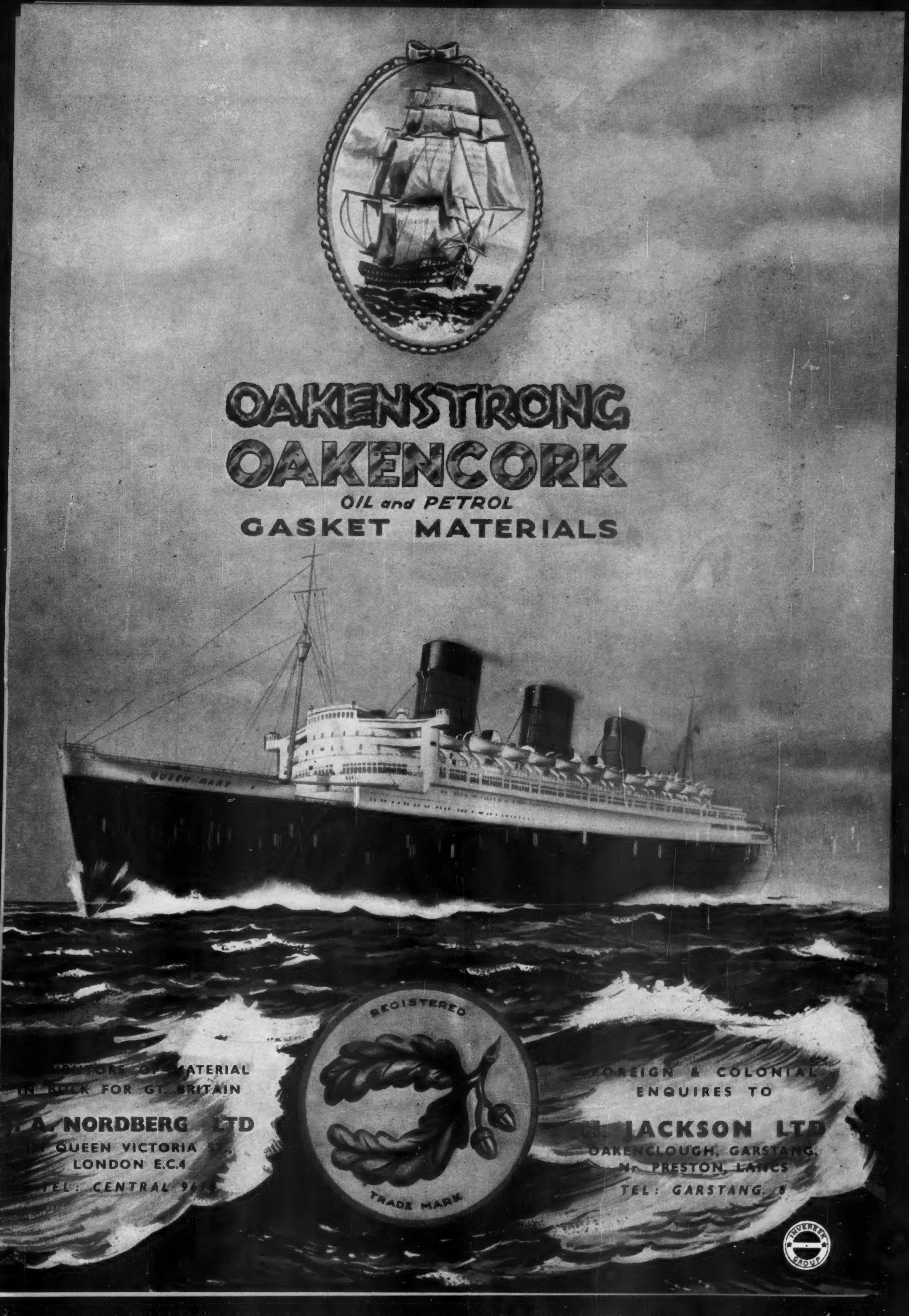
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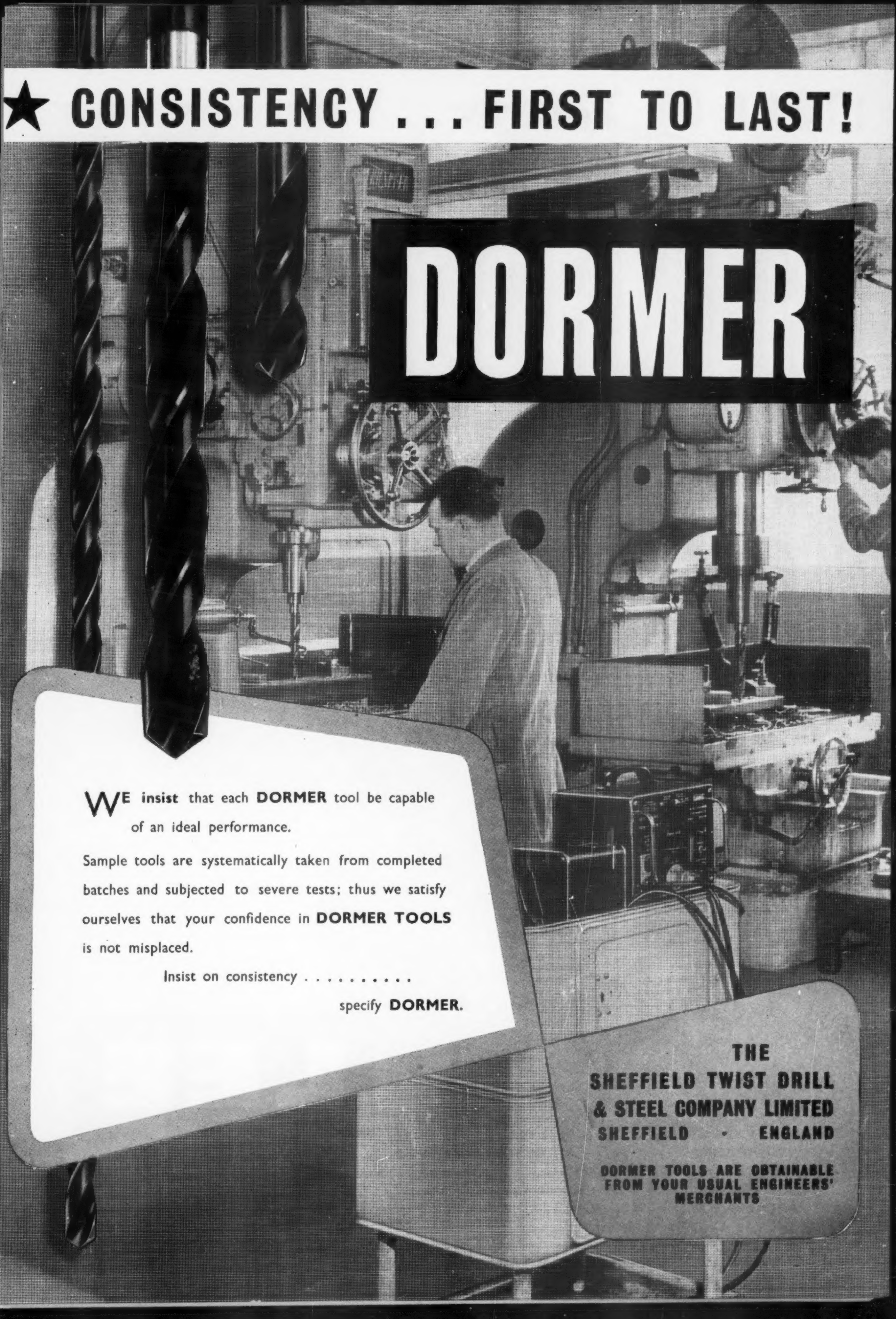
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Sample tools are systematically taken from completed batches and subjected to severe tests; thus we satisfy ourselves that your confidence in DORMER TOOLS is not misplaced.
Insist on consistency . . . .
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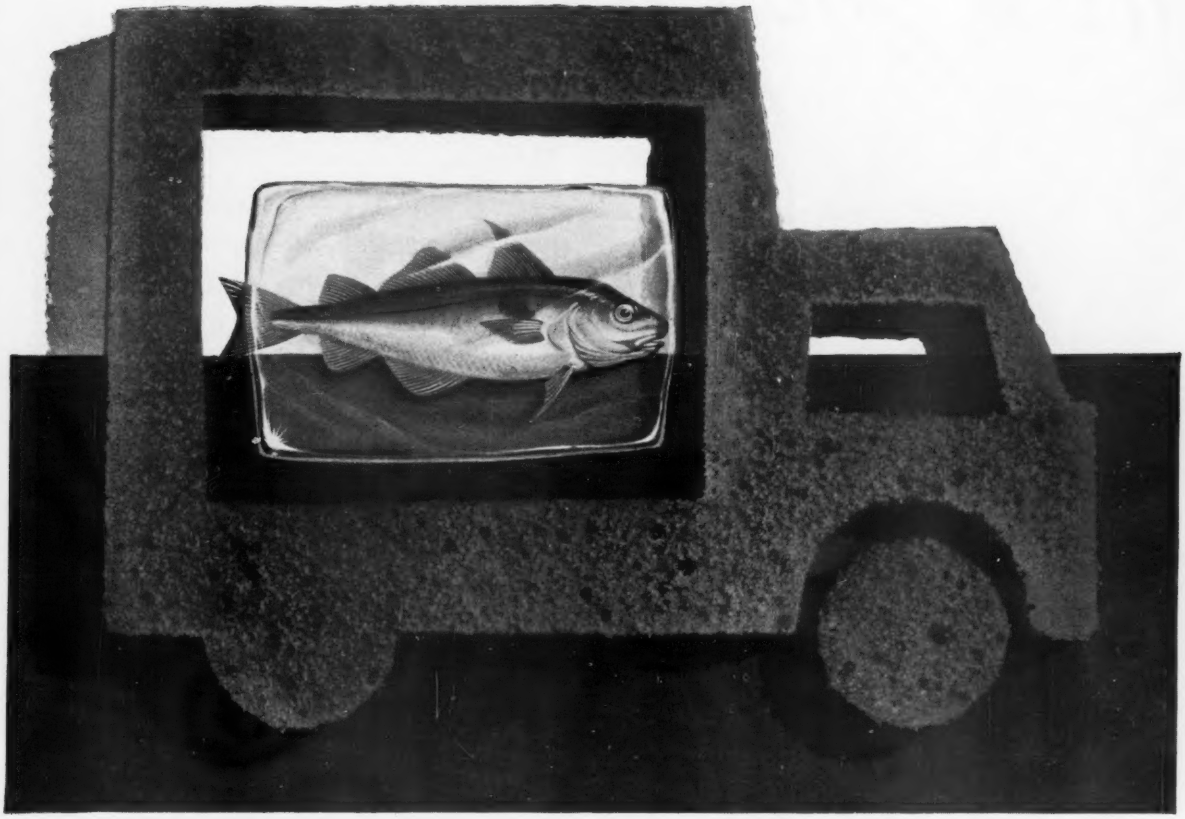
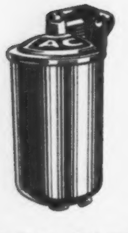
DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS



it's a good plan to include

AC-Delco QUALITY PRODUCTS



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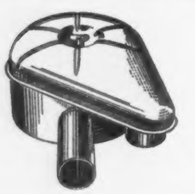

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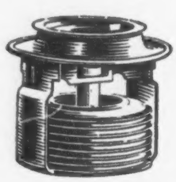
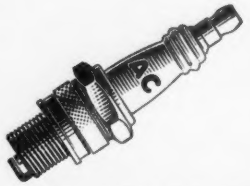
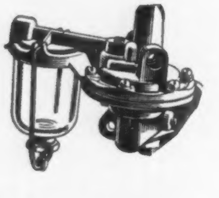


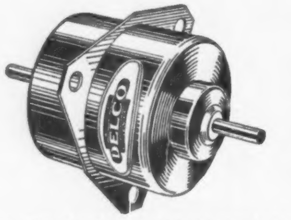
AC THERMOSTATS



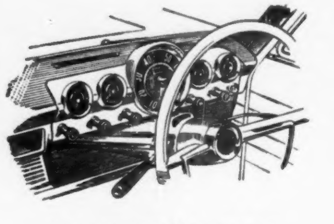
AC SPARK PLUGS



AC FUEL PUMPS



DELCO ELECTRIC MOTORS



AC INSTRUMENTS

Virtually every British car has one or more AC-Delco components designed into it on the drawing-board. AC-Delco research engineers will gladly help when you are planning a new design or modifying an existing one. Liaison at the drawing-board stage can help your design and production programme.

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THE NAME THAT CARRIES WEIGHT
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BEDFORD
Speed, f.p.m. ... 50
SLEWING—2 r.p.m. with load.
Turning Radius—20 ft.
Ground Clearance—11 ins.
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MODEL S710C
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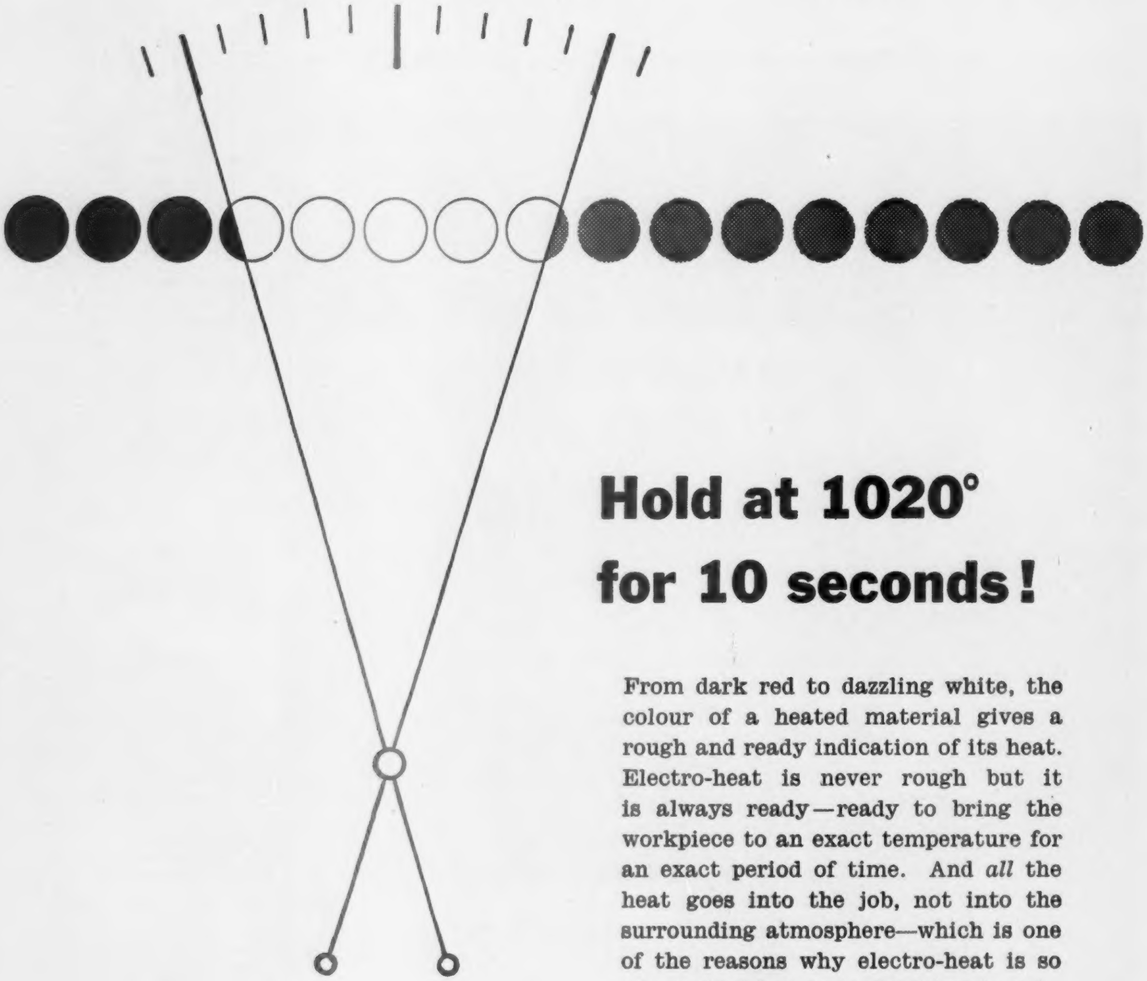
246




Whatever you do with the front end–
the Radiator design can be safely left to
CMF
COVENTRY MOTOR FITTINGS
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Switch from this

to this

and step up production . . .

For working within close limits, an Anglepoise is simply indispensable. However good a worker and his eyes may be, he must see the job. This applies in all fine work, drilling, assembling, etc., where instantly adjustable close-to-the-job lighting is a sheer necessity.

Anglepoise throws a clear, concentrated light right on and into the work, not in the operator's eyes, follows the job from any position or angle, degree by degree, at a finger-touch and 'stays put' in any required position—and out of the way when not needed. It needs only a low-powered bulb for high-class results—a big saving on the lighting bill (it can be supplied with a small shade for low voltage systems). Why not learn more about this fine lamp by sending for Booklet A?

TERRY Anglepoise LAMP

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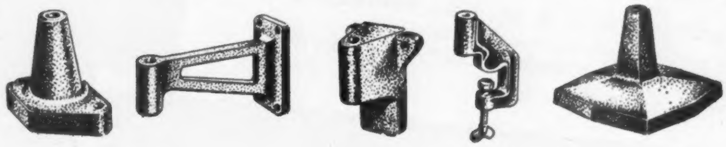
Sole Makers: HERBERT TERRY & SONS LTD · REDDITCH · WORCESTERSHIRE

*** A SUGGESTION FOR MACHINE MANUFACTURERS:—**
Why not fit your products with Anglepoise? We will submit samples on approval.



Some of the alternative bases for all models

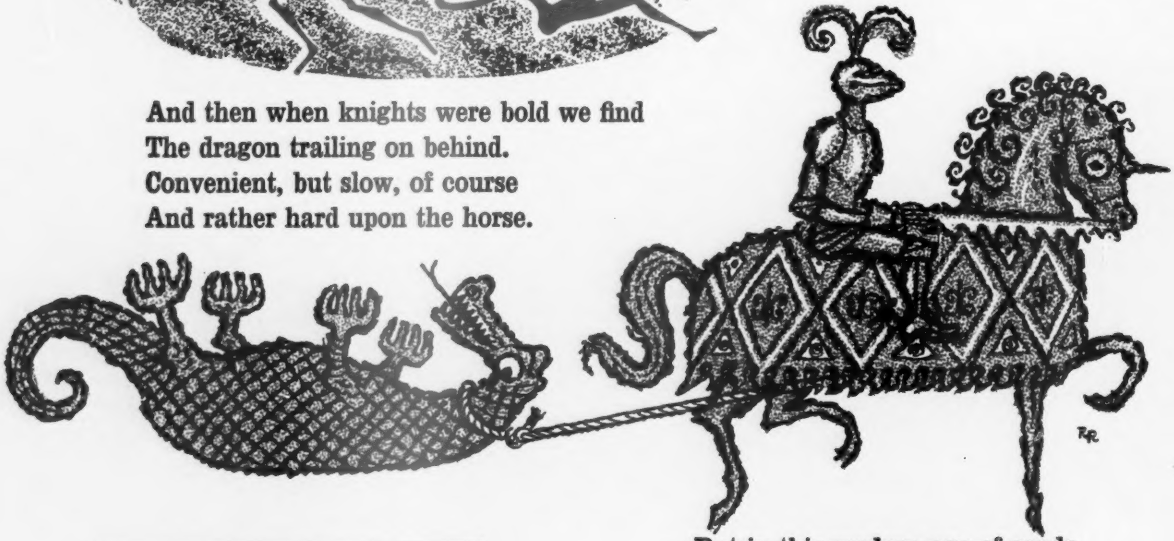
HT20


ARCHDALE
For Automation
PHOTOGRAPH BY COURTESY OF STANDARD MOTOR CO. LTD., COVENTRY, SHOWS ONE OF OUR TRANSFER MACHINES ENGAGED ON CYLINDER BLOCKS.
JAMES ARCHDALE & CO. LTD., BIRMINGHAM, 16.
A member of the Staveley Coal & Iron Co. Ltd. Group.
SOLE AGENT: ALFRED HERBERT LTD. COVENTRY.

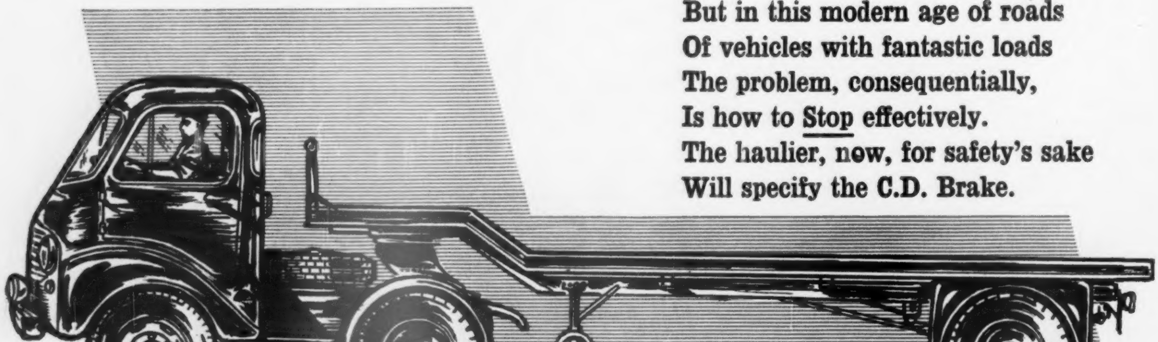
It's a different story now...

In prehistoric days, we feel
Before the advent of the wheel,
Our ancestor in nuptial bliss
Would drag his mate about like this.

And then when knights were bold we find
The dragon trailing on behind.
Convenient, but slow, of course
And rather hard upon the horse.



But in this modern age of roads
Of vehicles with fantastic loads
The problem, consequentially,
Is how to Stop effectively.
The haulier, now, for safety's sake
Will specify the C.D. Brake.



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CLAYTON DEWANDRE CO. LTD.

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G572/VAC1

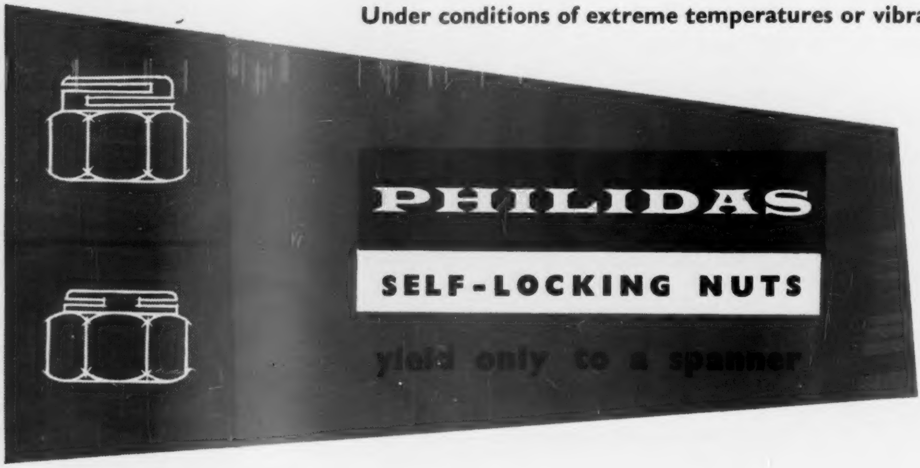
Photograph of Viscount aircraft by courtesy of British European Airways.

PHILIDAS make nuts that are tough through and through; all-metal one-piece nuts that stay put—totally unaffected by heat changes, vibration, oil and constant use. Other vital advantages: with their opposing torque cross-cuts feature Philidas self-locking nuts yield *only* to a spanner, and can be safely used over and over again. Progress wouldn't be secure without them.

Self-locking nuts in all standard threads, sizes, platings and finishes for the Aircraft, Automobile, Electrical and Engineering Industries. Wheel, Anchor, Strip Nuts, etc. in steel, brass, bronze, stainless steel or light alloy.

For safety, efficiency and economy. Philidas self-locking nuts are used by Vickers-Armstrongs Ltd., The Bristol Aeroplane Co. Ltd., Ford Motor Co., The Rover Co. Ltd., The General Electric Co. Ltd. and Auster Aircraft Ltd.

Under conditions of extreme temperatures or vibration—



PHILIDAS DIVISION OF WHITEHOUSE INDUSTRIES LIMITED

Ferrybridge, Knottingley, Yorks. Telephone: Knottingley 2323 (5 lines) Telex: 55-242. Telegrams: Balbearing Ferrybridge

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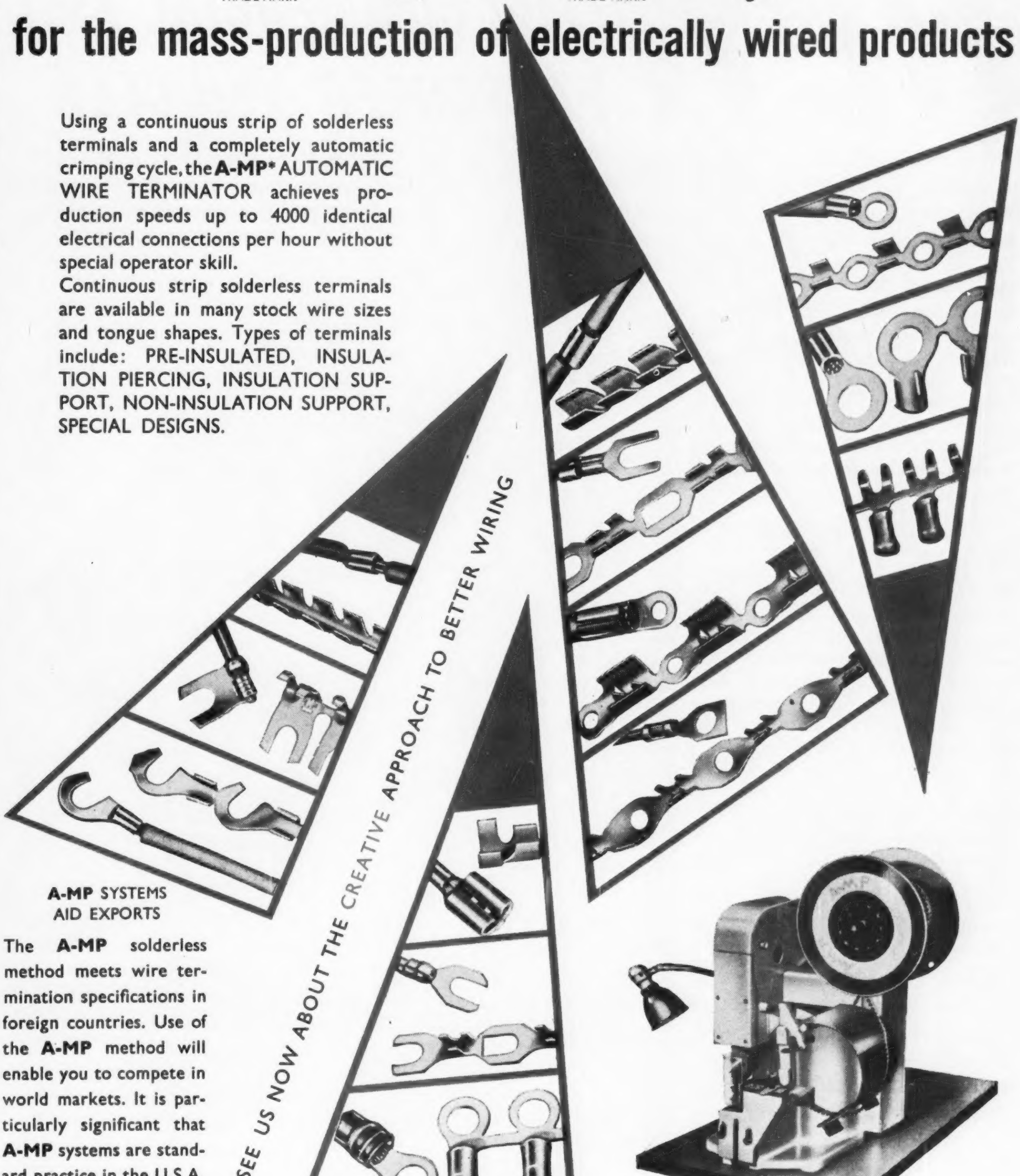
Using a continuous strip of solderless terminals and a completely automatic crimping cycle, the **A-MP*** AUTOMATIC WIRE TERMINATOR achieves production speeds up to 4000 identical electrical connections per hour without special operator skill.
Continuous strip solderless terminals are available in many stock wire sizes and tongue shapes. Types of terminals include: PRE-INSULATED, INSULATION PIERCING, INSULATION SUPPORT, NON-INSULATION SUPPORT, SPECIAL DESIGNS.



A-MP SYSTEMS
AID EXPORTS

The **A-MP** solderless method meets wire termination specifications in foreign countries. Use of the **A-MP** method will enable you to compete in world markets. It is particularly significant that **A-MP** systems are standard practice in the U.S.A.

A-MP*
TRADE MARK

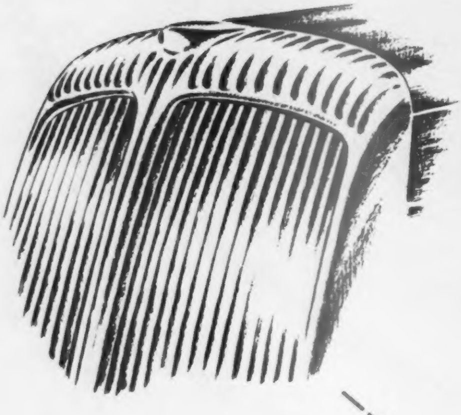
AIRCRAFT-MARINE PRODUCTS (GT. BRITAIN) LTD

London Office: DEPT. 12, 60 KINGLY STREET, LONDON W.1 Telephone: REGENT 2517-8 and 3681-2-3

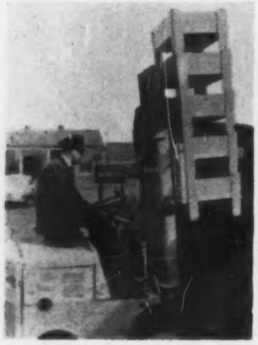
Works: SCOTTISH INDUSTRIAL ESTATES, PORT GLASGOW, SCOTLAND. *AP323/46*

* Trade Mark of AMP Incorporated, U.S.A.

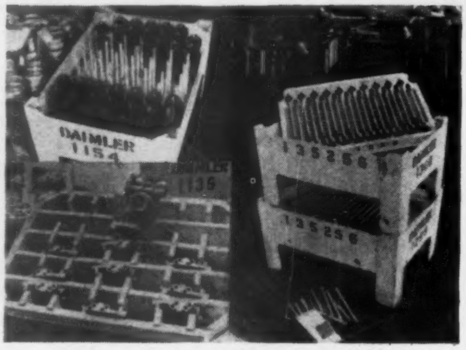
BACKGROUND TO *Perfection...*

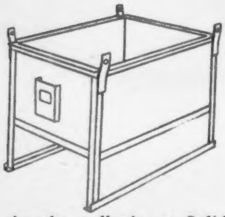


Knowing the reputation of Daimler, you will appreciate that anything to do with the production of their quality cars must be absolutely first-class. We will just say, therefore, that The Daimler Company Ltd. use Rubery Owen Pallets in their Coventry factory, contributing to inimitable Daimler efficiency at every stage of production and storage



A popular pallet in use is the Rubery Owen B. P. 6 which has great versatility. Freely stackable up to 8 high. Can be transported by stillage truck or fork truck. Note how Daimler employ interior trays to protect high class work in progress.





Another pallet in use. Solid box type. Reinforced top edge. Guide rails provide ease of stacking between locating ears. Ample ground clearance for stillage truck as well as fork truck.

Daimler *palletise* OWEN-*wise*

RUBERY, OWEN & CO. LTD., INDUSTRIAL STORAGE EQUIPMENT DIVISION, WHITEGATE FACTORY, WREXHAM, N. WALES

Telephone: WREXHAM 3566-8

Territory Offices: London, Coventry, Manchester, Southampton, Bristol, Glasgow, Darlaston (Staffs).

Member of the Owen Organisation

B57/F

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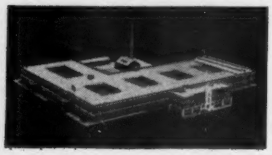

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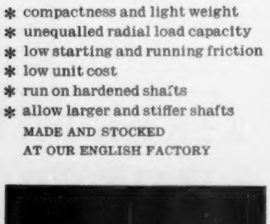

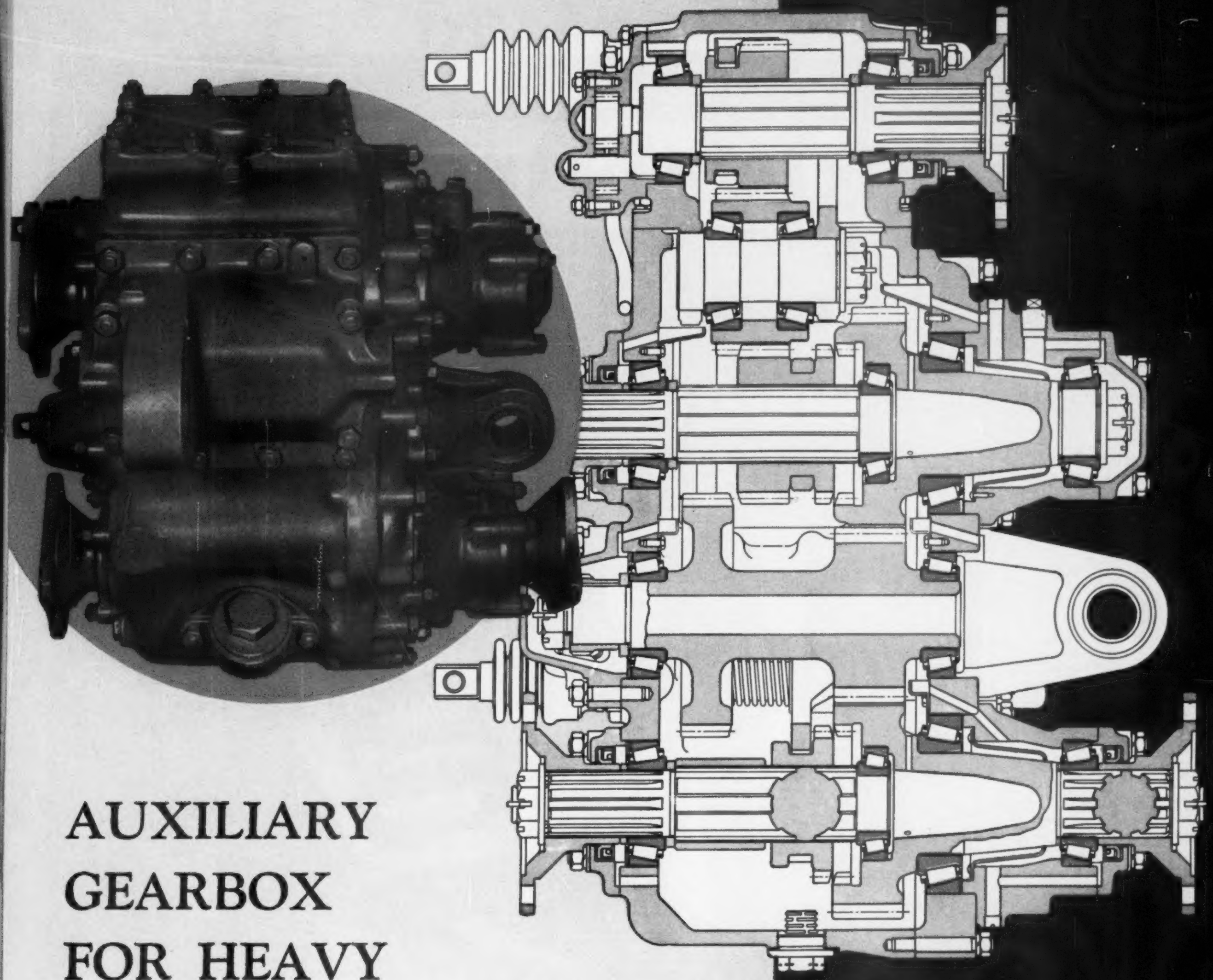

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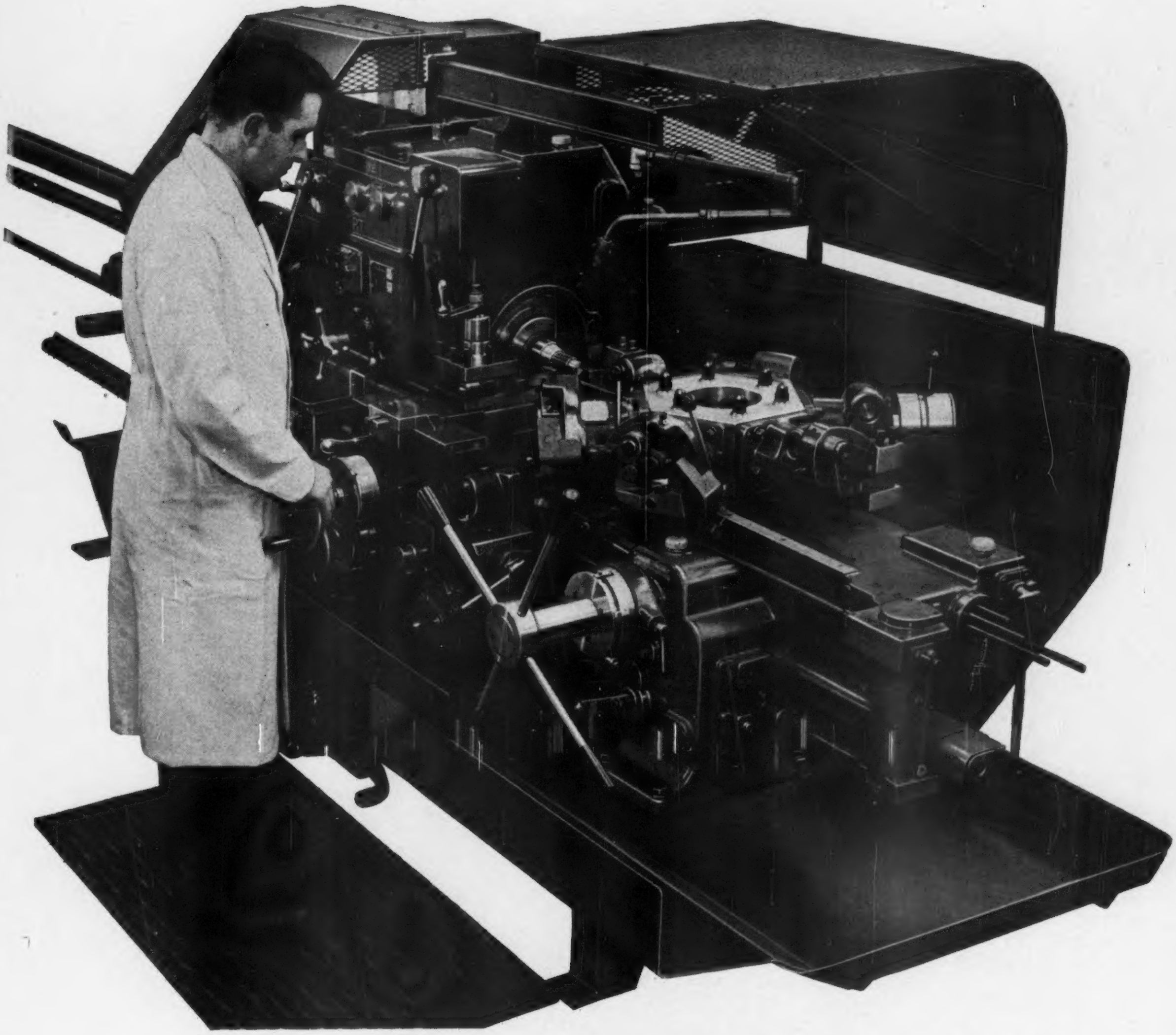

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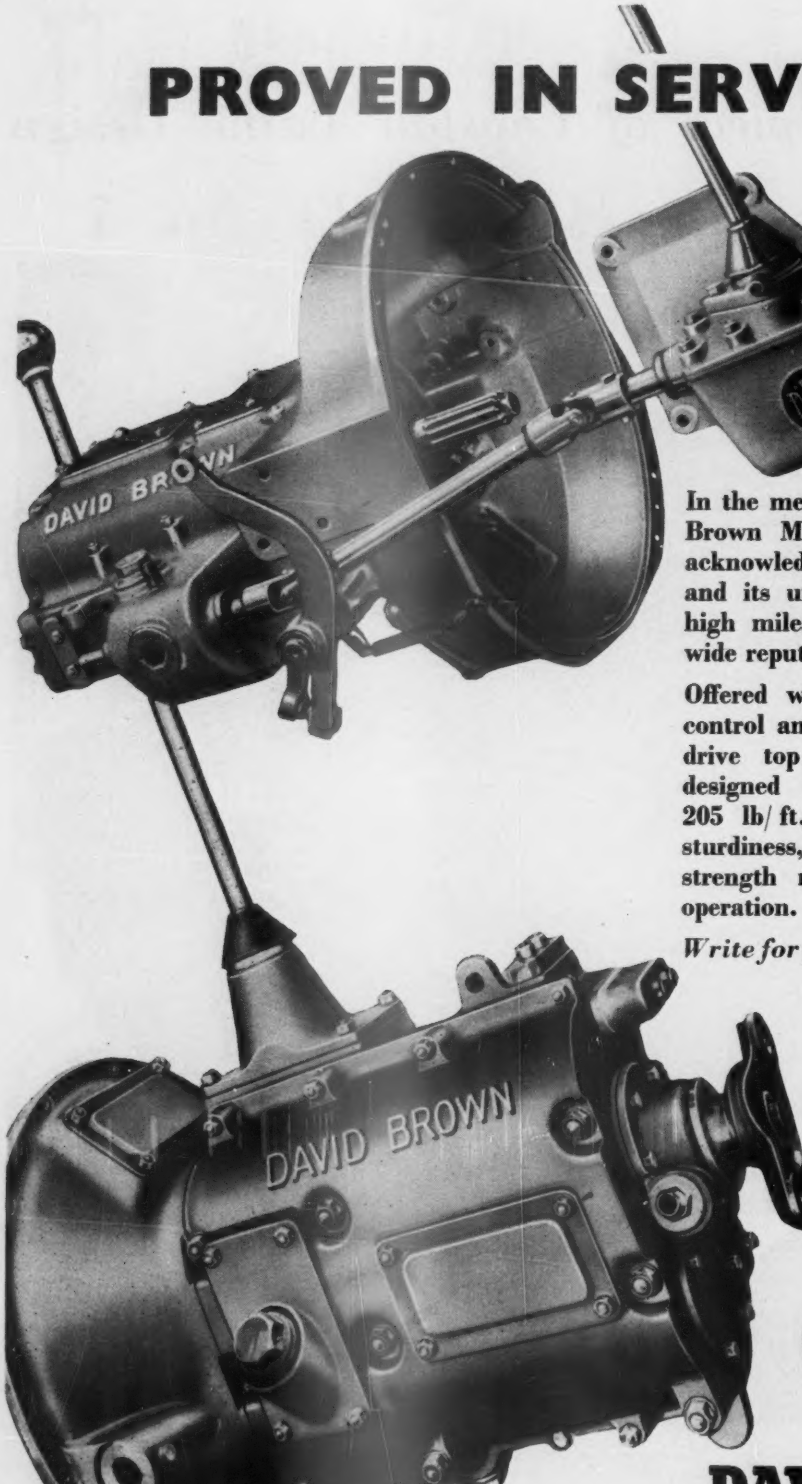

In the medium vehicle range, the David Brown Model 542 5-speed gearbox is acknowledged as the outstanding unit, and its unfailing reliability, over very high mileages, has earned it a world-wide reputation.

Offered with either centre or forward control and a choice of direct or over-drive top gear, the 542 gearbox is designed for a maximum torque of 205 lb/ ft. and is characterised by its sturdiness, compactness, low weight to strength ratio, ease and quietness of operation.

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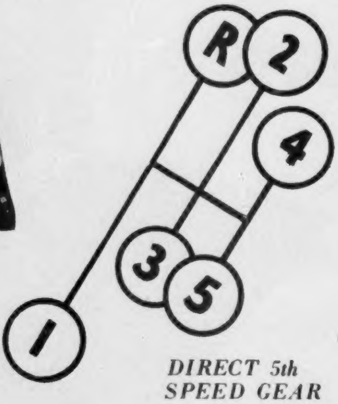

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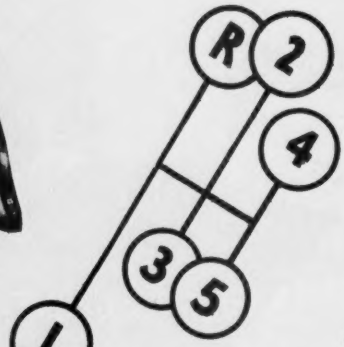

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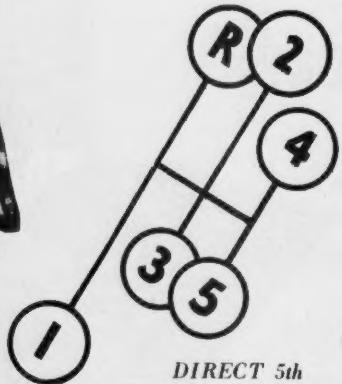

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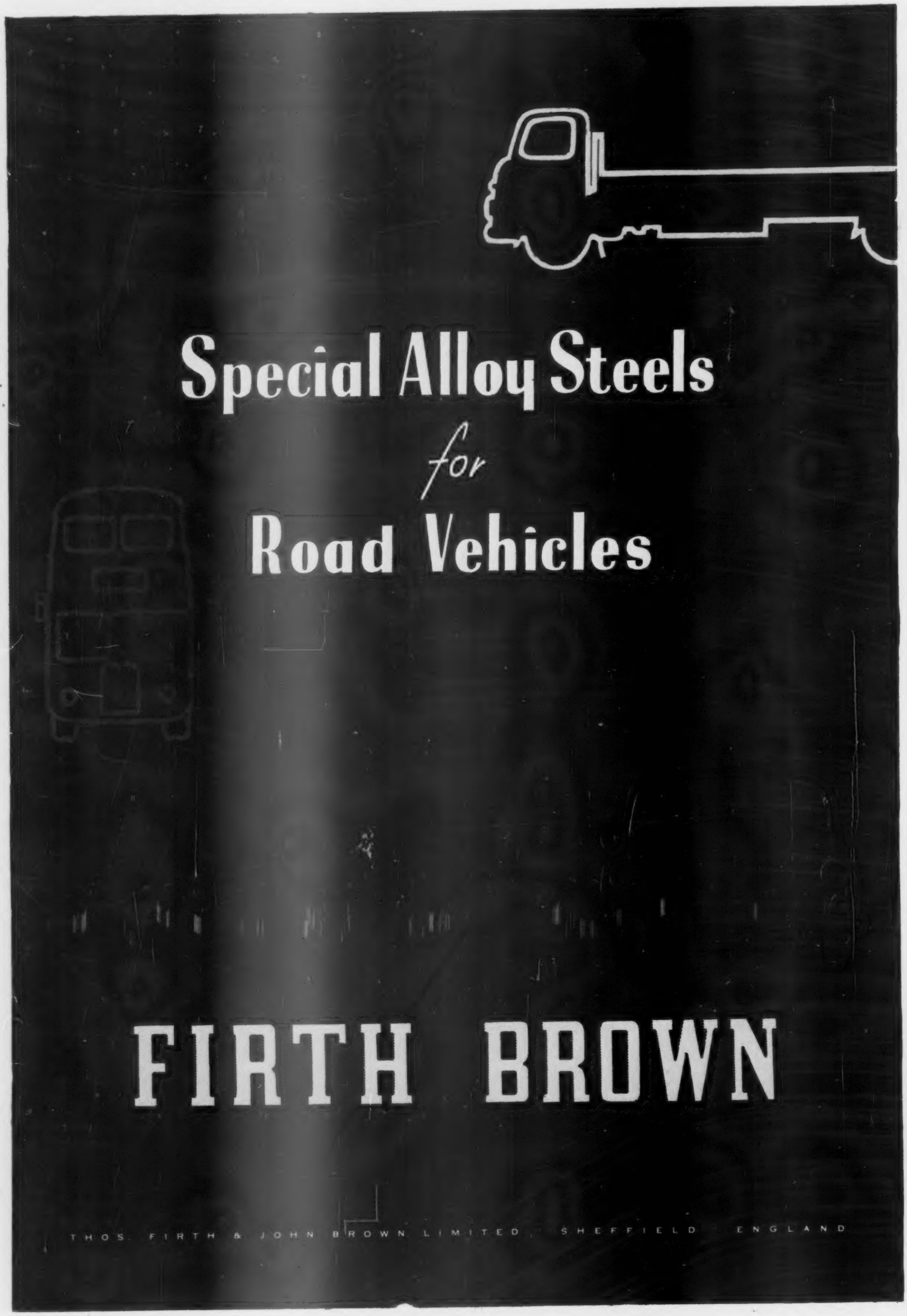
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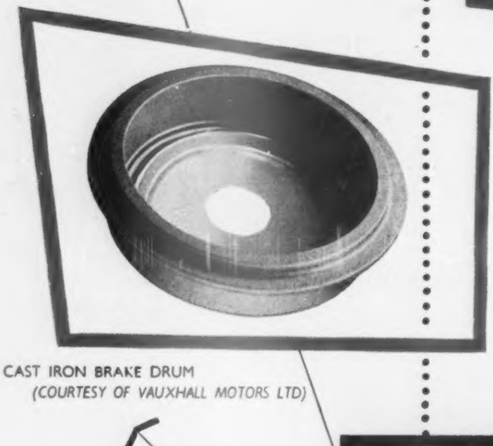

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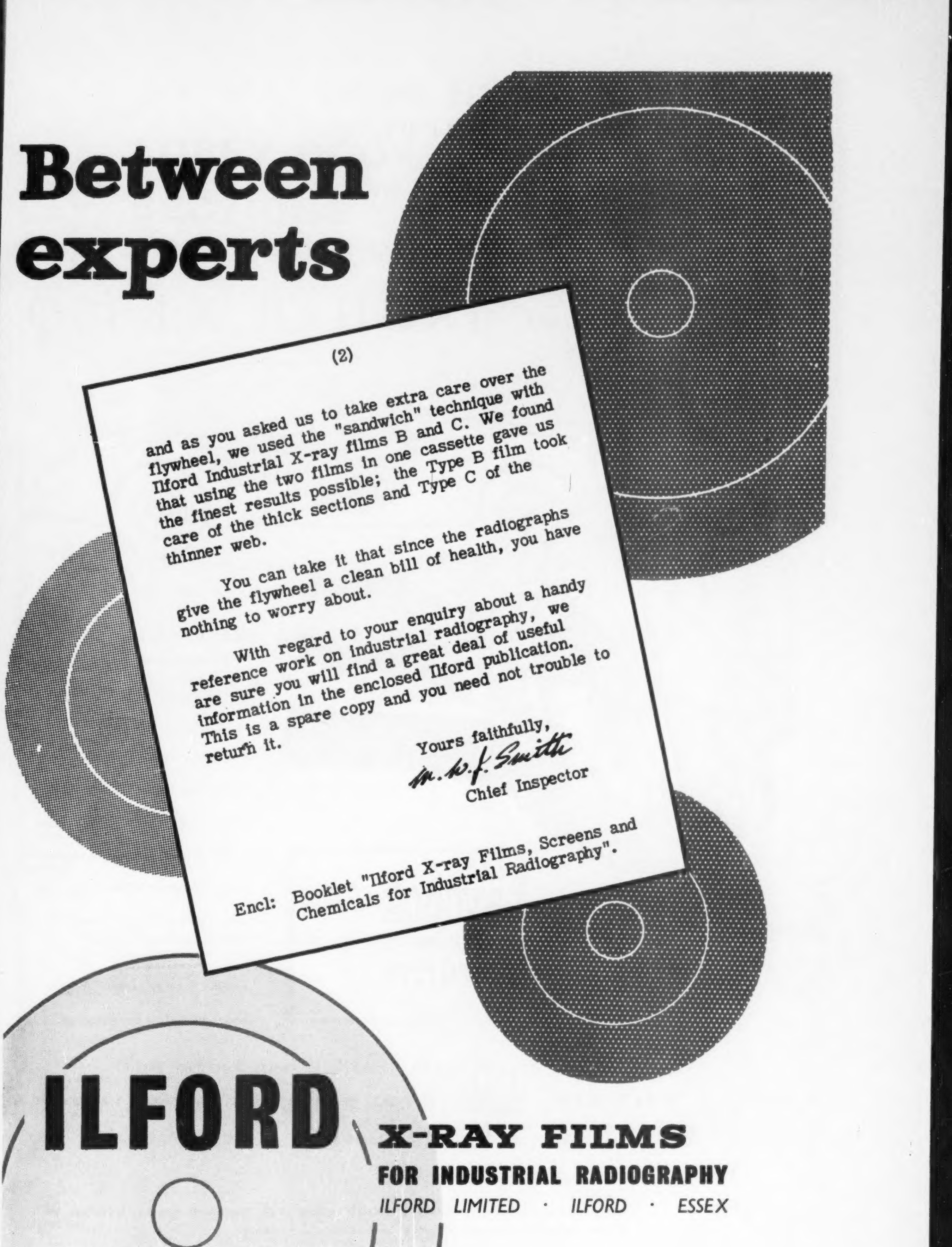

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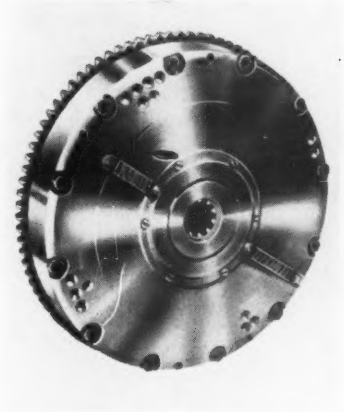

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VOLUME 47 NUMBER 9 SEPTEMBER 1957

The Conquest of Friction

Following the success of the bicycle as a means of popular transport, many of the cycle manufacturers started to make horseless carriages, and they naturally applied to the 'motor car' their experience of ball bearings for mounting road wheels, sprocket axles and other revolving parts. The rapid growth of the automobile industry further widened the field for rolling bearings and gave impetus to their design and to much extended manufacturing facilities. Today the automobile industry is collectively one of the largest consumers of SKF ball and roller bearings.

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F. C. Sheffield

DESIGN MATERIALS **AUTOMOBILE ENGINEER** PRODUCTION METHODS WORKS EQUIPMENT

Small Cars

IT is an open secret that some of the large automobile manufacturers in this country have been investigating the potential value of developing a much smaller car, with an engine capacity of some 500 cm³, than they have hitherto produced. This is not surprising. Today, the British automobile industry *vis-a-vis* its Continental competitors is in a position analogous to that of the American industry *vis-a-vis* the British. In both countries, foreign producers are filling a demand that cannot be met from domestic products. In America it is obvious that there is a market for cars much smaller than those produced by the home industry, and because of this, the manufacturers have been giving serious thought to the advisability of embarking on completely new lines of production. However, all the evidence shows that until British and Continental competition makes much greater inroads in the American market, the American manufacturers will continue to concentrate on their huge vehicles.

In this country also, there is a market for smaller cars than those produced here—how large the market is, no one knows. Its size is, however, a matter of fundamental importance, since without a home demand sufficient to cushion the inevitable fluctuations in export markets, it would be unwise, to say the least, to embark upon the very large scale production that would be necessary.

There are two arguments, and two only, that can be advanced in favour of the very small car—here we refer to a conventional vehicle and not to bubble cars. The first is running economy, which everyone will admit can be achieved. The second is low first price, a much more difficult goal. In fact, we doubt whether a completely new design with an engine capacity in the order of 500 cm³ would be appreciably cheaper than the smallest current British models.

For a very small car to have any prospect of large sales in this country, the basic price would have to be very much lower than that of any established model. To break into the Continental market where there are already well-established competitors, Fiat, Citroen and Lloyd spring readily to mind, would be even more difficult. Merely to produce a scaled down version of a larger car, with equivalent trim, finish and instrumentation, will not suffice. Something much more radical will be called for.

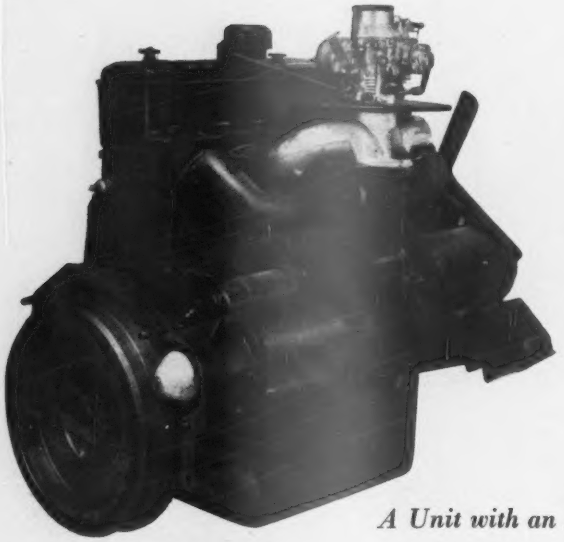
In general, there is reasonably close agreement between the price per lb for the smaller and rather larger cars produced in the same factory. It can, therefore, be taken that for similar quality of trim, finish and instrumentation, the reduction in price will, within fairly close limits, vary directly with the reduction in weight. Therefore, for a price reduction in the order of 20 per cent, and anything less would not be sufficient to create a market, there must be either a 20 per cent weight reduction or the quality of trim, finish and instrumentation would have to be lowered to compensate for any smaller reduction.

The development of a very small car would certainly pose strange problems to the designer, and would certainly call for departures from conventional British practice. For example, in all probability the necessity for keeping costs down will entail the use of a rear-mounted, twin cylinder, air-cooled engine. But the British motorist is accustomed to a relatively smooth running, reasonably quiet engine with four or six cylinders; to get equivalent smoothness and quiet running from an air-cooled, twin cylinder power unit will not be easy.

Nor will it be easy to organize the production of a very small car. It is a common complaint against the British automobile industry that they produce too great a number of models, but the multiplicity is more apparent than real. In all the large organizations there are many parts that are common to two or more models. For example, liaison between the design and production departments has, in some factories, made it possible to machine cylinder blocks for four and six-cylinder engines on one line, and a single line also suffices for pistons and connecting rods. This gives maximum machine utilization, an important factor when the capital investment for large scale production is so enormous.

To consider only one aspect of production, the manufacture of a 500 cm³ engine would necessitate the installation of new production lines, since the various components could not be accommodated on any of the existing lines. Production would call for one of two things. Either an existing model could be dropped and the facilities so freed adapted, so far as possible, to suit the new components; or a completely new production line could be installed. It is unthinkable, that any organization would take the first alternative as long as its existing models were selling well, and at the moment they are. Nor is the second alternative much more attractive.

When all the facts are taken into account, there is no doubt that the arguments against are stronger than those for the development of a very small car in this country. The probable reduction in basic price would not be large enough to cause any great expansion in the home market, while entering the Continental market, which is the main outlet for these vehicles, would be very difficult in face of the established European competition.



RENAULT 2·1 LITRE ENGINE

A Unit with an Aluminium Alloy Cylinder Head and Wet Liners

OPERATION of the Renault 2·1 litre engine for a number of years in the Frégate Affaire, Admiral, Grand Pavois and Domaine vehicles has resulted in its development to the point where a completely satisfactory compromise between performance and reliability has been achieved. In short, the unit can be regarded as fully developed and proved. Among its noteworthy features are: an aluminium cylinder head with integrally cast rocker pedestals; the incorporation of wet liners; pistons of unusual design; and the timing drive is effected by helical gears, the half-speed wheel being of fabric-reinforced plastics. Although in other respects the engine is of more or less conventional design, the manufacturers have departed from traditional practice in one or two details, which will be elaborated upon later.

A bore : stroke ratio of 1·035:1 was originally adopted and the connecting rod length:stroke ratio was 1·82:1. However, in later models the bore was increased from 85 mm to 88 mm, giving a bore:stroke ratio of 1:1. At the speed at which maximum b.h.p. is developed, the mean piston speed is 2,410 ft/min. The maximum b.m.e.p. in the earlier model was 119 lb/in² at 2,300 r.p.m., but is now 128 lb/in² at 2,600 r.p.m. Thus, whereas the ratio of the speed at maximum torque to that at maximum b.h.p. was 0·55:1, and the ratio of maximum torque to torque at maximum b.h.p. was 1·27:1, these figures are now 0·62:1 and 1·31:1 respectively. The corresponding values of maximum b.h.p. developed per litre are 31·5 and 32·4. The engine weighs 340 lb dry, so the figure for the b.h.p. developed per pound is 0·204. The overall dimensions of the engine, less air filter and flywheel are: height 26½ in, width 19¼ in and length 27 in.

The engine mounting arrangement is fairly conventional. An obtuse angle V-arrangement is used at the front, the rubber sandwich units being interposed between brackets bolted to the front plate of the engine and on top of the longitudinal members of the vehicle structure. At the rear, an acute V-angle layout has been adopted, with a rubber sandwich type unit on each side interposed between a cast iron bracket bolted to the rear face of the gearbox and a pressed steel bracket bolted to the longitudinal member of the vehicle structure. Torque reaction stops are incorporated in each rear mounting. They are formed simply by the flanges of a channel section plate, the inner faces of which have rubber bonded to them. The main rubber sandwich unit seats in the channel, between these flanges.

Axial location is effected by means of a 12 mm diameter tie rod, which has at the rear end an eye for a rubber bush. This eye and bush assembly is secured between lugs welded to a frame cross member behind the gearbox. The front end of the tie rod is passed through a clearance hole in the bracket that carries the rear mountings of the engine and gearbox assembly. Two circular rubbers are spigoted into the clearance hole, one from the front and the other from the rear, and the assembly, which is not unlike the arrangement commonly employed on telescopic shock absorbers, is retained between two nuts and large dished washers. The end nut is locked by a split pin, while the other is locked by a third nut tightened against it. Thus, it is easy to adjust the precompression in this rubber fitting to effect a compromise between the requirements for firm location to prevent clutch judder and adequate resilience to avoid the transmission of vibration and noise to the body. The engine installation angle is 3¾ deg from horizontal.

SPECIFICATION

Four cylinders. Bore and stroke 88 mm and 88 mm respectively. Swept volume 2,141 cm³. Maximum b.h.p. 69·5 at 4,200 r.p.m. Maximum b.m.e.p. and torque 128 lb/in² and 15·35 m-kg (110·5 lb-ft) respectively at 2,600 r.p.m. Compression ratio 7:1 Cast steel, three-bearing crankshaft. Overhead valves, operated by push rods. Solex 32 PICBT carburettor. Mechanical fuel lift pump.

Cylinder block and crankcase

The wet liners are of a cast iron containing C 3·2-3·5 per cent, Si 1·7-2·2 per cent and P maximum 0·3 per cent, and having an ultimate tensile strength of 32 kg/mm². Their lower ends are flanged and spigoted into holes in the lower deck of the cylinder block. Sealing is effected by copper washers between the flanges and the lower deck, which is thickened locally to a depth of 26 mm by the incorporation of bosses round the holes. These bosses are supported by the end walls and transverse ribs in the crankcase to form a rigid base for the liner assembly. The central rib extends the full depth of the crankcase to house the main journal bearing, but the two intermediate ones are arched to clear the inclined arms of the crankshaft.

Above the lower decking, the jacket of the cylinder block

is divided in two by a transverse web which, in effect, forms a vertical extension of the central rib in the crankcase. This web has a large hole cored in it to allow water to pass through from end to end of the block. It stiffens the block and also deflects the water transversely inwards between the liners. Each half of the block, of course, contains two liners, the flanges of which have flats machined on them where they butt together. Between the liners of each pair, the minimum water jacket space is 5 mm; thus the spacing between the liner axes is 103 mm. The spacing between numbers 2 and 3 liners is 36 mm. Each liner is 92 mm outside diameter at its spigot end. The diameters of the lower and upper flanges are 101 mm and 105 mm respectively. Between the flanges, the outside diameter of the liner is 98 mm. The jacket and crankcase walls are 5 mm thick, while the upper and lower decks are 7½ mm thick.

The front face of the block is machined in one plane to receive the water pump, and the front plate and timing cover. A small cell cored in this end of the block forms the housing for the water pump rotor. The joint faces at the rear end of the crankcase are also machined in a single plane: one is for the flywheel housing; the other is for the two-piece aluminium alloy casting that surrounds the oil return scroll on the crankshaft, and which is spigoted into the rear face of the rear main journal bearing housing and cap.

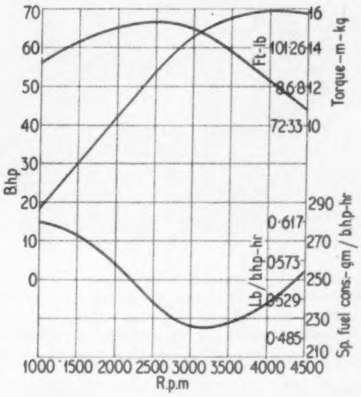
An unusual feature of the return scroll is that the sides of the spiral groove are raked, instead of perpendicular to the axis of the shaft. The angle of rake is approximately 25 deg. A lip is formed round the aperture in which the return grooves operate, so that the oil that drains down the inner face of the casting does not fall directly on the shaft. Immediately in front of this lipped aperture is an oil thrower ring, machined integrally on the shaft. Oil flung off this ring into the space between the aluminium alloy casting and the main journal bearing cap and housing is drained through two 10 mm diameter holes in the cap and drops into the sump.

Rubberized cork sealing strips are interposed between the peripheries of semi-circular flanges round the front and rear bearing caps and lipped semi-circular cut-outs in the ends of the pressed steel sump. Each of the three main journal bearing caps is held down by two 14 mm diameter waisted bolts of 38C4h, 0·80-1·10 per cent chromium steel; this specification and all the others quoted in this article are from the French Standard PN R 971-01 (BNA448). Location is effected by short, 18 mm diameter, tubular dowels round the bolts. The short intermediate bearing cap has a single stiffening rib round its periphery, while each of the other two is stiffened by a flange and a rib.

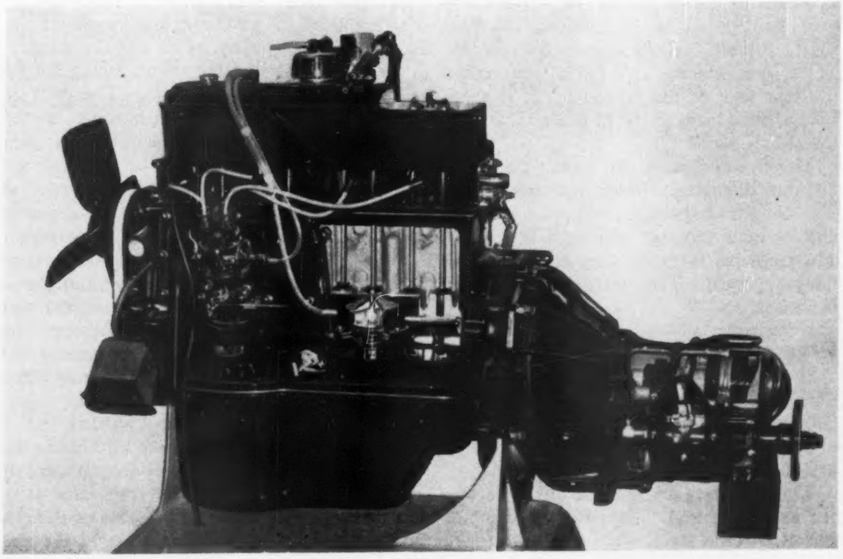
Crankshaft and flywheel

A fully-balanced, three-bearing, four-throw crankshaft is employed. It is of a cast steel, containing C 1·2-1·45, Si 0·80-1·20, Mn 0·50-0·80, Cr 0·30-0·60, Cu 1·50-2·00, and S, P and Ni not more than 0·08, 0·10 and 0·20 per cent respectively. This material, after heat treatment, has an ultimate tensile strength of 70-90 kg/mm². Each journal is 55 mm diameter. Vandervell, white metal lined, shell type bearings are employed. Their effective lengths are: front 39 mm, centre 43 mm and rear 48 mm. Each shell is a 0·25 mm interference fit in the housing and the diametral running clearance is 0·031-0·059 mm. The overall length of the crankshaft between the front of the front web and the back of the rear web is 422 mm. All four webs are 20 mm thick and 77½ mm wide, and the two inclined crank arms are 38 mm thick and 76 mm wide. The crank pins are 55 mm diameter. Axial location is effected at the centre bearing by means of semi-circular thrust washers housed in recesses in the front and rear ends of both the cap and housing.

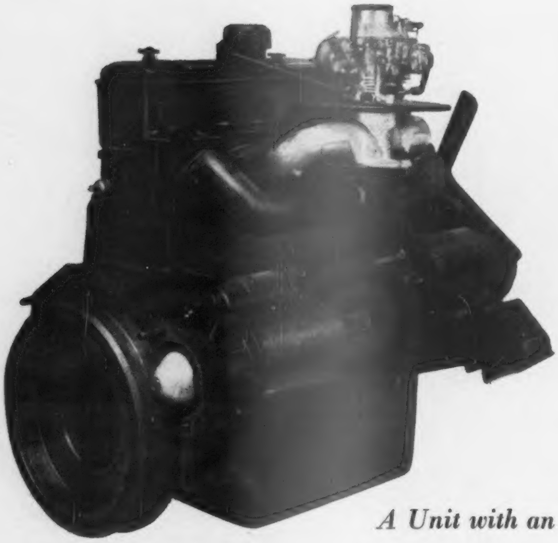
A flange is formed on the rear end of the shaft to receive the flywheel, which is spigoted on and secured by six 10 mm diameter set bolts. Accurate location of the flywheel is effected by two dowels. A counterbore in the end of the



Engine performance curves obtained with the fan fitted, but without an air filter



Left-hand side of the engine and transmission assembly, sectioned for display. This side of the sump is shaped in such a way as to clear the drive for the oil pump and distributor units



RENAULT 2·1 LITRE ENGINE

A Unit with an Aluminium Alloy Cylinder Head and Wet Liners

OPERATION of the Renault 2·1 litre engine for a number of years in the Frégate Affaire, Admiral, Grand Pavois and Domaine vehicles has resulted in its development to the point where a completely satisfactory compromise between performance and reliability has been achieved. In short, the unit can be regarded as fully developed and proved. Among its noteworthy features are: an aluminium cylinder head with integrally cast rocker pedestals; the incorporation of wet liners; pistons of unusual design; and the timing drive is effected by helical gears, the half-speed wheel being of fabric-reinforced plastics. Although in other respects the engine is of more or less conventional design, the manufacturers have departed from traditional practice in one or two details, which will be elaborated upon later.

A bore : stroke ratio of 1·035:1 was originally adopted and the connecting rod length:stroke ratio was 1·82:1. However, in later models the bore was increased from 85 mm to 88 mm, giving a bore:stroke ratio of 1:1. At the speed at which maximum b.h.p. is developed, the mean piston speed is 2,410 ft/min. The maximum b.m.e.p. in the earlier model was 119 lb/in² at 2,300 r.p.m., but is now 128 lb/in² at 2,600 r.p.m. Thus, whereas the ratio of the speed at maximum torque to that at maximum b.h.p. was 0·55:1, and the ratio of maximum torque to torque at maximum b.h.p. was 1·27:1, these figures are now 0·62:1 and 1·31:1 respectively. The corresponding values of maximum b.h.p. developed per litre are 31·5 and 32·4. The engine weighs 340 lb dry, so the figure for the b.h.p. developed per pound is 0·204. The overall dimensions of the engine, less air filter and flywheel are: height 26½ in, width 19¼ in and length 27 in.

The engine mounting arrangement is fairly conventional. An obtuse angle V-arrangement is used at the front, the rubber sandwich units being interposed between brackets bolted to the front plate of the engine and on top of the longitudinal members of the vehicle structure. At the rear, an acute V-angle layout has been adopted, with a rubber sandwich type unit on each side interposed between a cast iron bracket bolted to the rear face of the gearbox and a pressed steel bracket bolted to the longitudinal member of the vehicle structure. Torque reaction stops are incorporated in each rear mounting. They are formed simply by the flanges of a channel section plate, the inner faces of which have rubber bonded to them. The main rubber sandwich unit seats in the channel, between these flanges.

SPECIFICATION

Four cylinders. Bore and stroke 88 mm and 88 mm respectively. Swept volume 2,141 cm³. Maximum b.h.p. 69·5 at 4,200 r.p.m. Maximum b.m.e.p. and torque 128 lb/in² and 15·35 m-kg (110·5 lb-ft) respectively at 2,600 r.p.m. Compression ratio 7:1 Cast steel, three-bearing crankshaft. Overhead valves, operated by push rods. Solex 32 PICBT carburettor. Mechanical fuel lift pump.

Axial location is effected by means of a 12 mm diameter tie rod, which has at the rear end an eye for a rubber bush. This eye and bush assembly is secured between lugs welded to a frame cross member behind the gearbox. The front end of the tie rod is passed through a clearance hole in the bracket that carries the rear mountings of the engine and gearbox assembly. Two circular rubbers are spigoted into the clearance hole, one from the front and the other from the rear, and the assembly, which is not unlike the arrangement commonly employed on telescopic shock absorbers, is retained between two nuts and large dished washers. The end nut is locked by a split pin, while the other is locked by a third nut tightened against it. Thus, it is easy to adjust the precompression in this rubber fitting to effect a compromise between the requirements for firm location to prevent clutch judder and adequate resilience to avoid the transmission of vibration and noise to the body. The engine installation angle is 3¾ deg from horizontal.

Cylinder block and crankcase

The wet liners are of a cast iron containing C 3·2-3·5 per cent, Si 1·7-2·2 per cent and P maximum 0·3 per cent, and having an ultimate tensile strength of 32 kg/mm². Their lower ends are flanged and spigoted into holes in the lower deck of the cylinder block. Sealing is effected by copper washers between the flanges and the lower deck, which is thickened locally to a depth of 26 mm by the incorporation of bosses round the holes. These bosses are supported by the end walls and transverse ribs in the crankcase to form a rigid base for the liner assembly. The central rib extends the full depth of the crankcase to house the main journal bearing, but the two intermediate ones are arched to clear the inclined arms of the crankshaft.

Above the lower decking, the jacket of the cylinder block

is divided in two by a transverse web which, in effect, forms a vertical extension of the central rib in the crankcase. This web has a large hole cored in it to allow water to pass through from end to end of the block. It stiffens the block and also deflects the water transversely inwards between the liners. Each half of the block, of course, contains two liners, the flanges of which have flats machined on them where they butt together. Between the liners of each pair, the minimum water jacket space is 5 mm; thus the spacing between the liner axes is 103 mm. The spacing between numbers 2 and 3 liners is 36 mm. Each liner is 92 mm outside diameter at its spigot end. The diameters of the lower and upper flanges are 101 mm and 105 mm respectively. Between the flanges, the outside diameter of the liner is 98 mm. The jacket and crankcase walls are 5 mm thick, while the upper and lower decks are 7½ mm thick.

The front face of the block is machined in one plane to receive the water pump, and the front plate and timing cover. A small cell cored in this end of the block forms the housing for the water pump rotor. The joint faces at the rear end of the crankcase are also machined in a single plane: one is for the flywheel housing; the other is for the two-piece aluminium alloy casting that surrounds the oil return scroll on the crankshaft, and which is spigoted into the rear face of the rear main journal bearing housing and cap.

An unusual feature of the return scroll is that the sides of the spiral groove are raked, instead of perpendicular to the axis of the shaft. The angle of rake is approximately 25 deg. A lip is formed round the aperture in which the return grooves operate, so that the oil that drains down the inner face of the casting does not fall directly on the shaft. Immediately in front of this lipped aperture is an oil thrower ring, machined integrally on the shaft. Oil flung off this ring into the space between the aluminium alloy casting and the main journal bearing cap and housing is drained through two 10 mm diameter holes in the cap and drops into the sump.

Rubberized cork sealing strips are interposed between the peripheries of semi-circular flanges round the front and rear bearing caps and lipped semi-circular cut-outs in the ends of the pressed steel sump. Each of the three main journal bearing caps is held down by two 14 mm diameter waisted bolts of 38C4h, 0·80-1·10 per cent chromium steel; this specification and all the others quoted in this article are from the French Standard PN R 971-01 (BNA448). Location is effected by short, 18 mm diameter, tubular dowels round the bolts. The short intermediate bearing cap has a single stiffening rib round its periphery, while each of the other two is stiffened by a flange and a rib.

Crankshaft and flywheel

A fully-balanced, three-bearing, four-throw crankshaft is employed. It is of a cast steel, containing C 1·2-1·45, Si 0·80-1·20, Mn 0·50-0·80, Cr 0·30-0·60, Cu 1·50-2·00, and S, P and Ni not more than 0·08, 0·10 and 0·20 per cent respectively. This material, after heat treatment, has an ultimate tensile strength of 70-90 kg/mm². Each journal is 55 mm diameter. Vandervell, white metal lined, shell type bearings are employed. Their effective lengths are: front 39 mm, centre 43 mm and rear 48 mm. Each shell is a 0·25 mm interference fit in the housing and the diametral running clearance is 0·031-0·059 mm. The overall length of the crankshaft between the front of the front web and the back of the rear web is 422 mm. All four webs are 20 mm thick and 77½ mm wide, and the two inclined crank arms are 38 mm thick and 76 mm wide. The crank pins are 55 mm diameter. Axial location is effected at the centre bearing by means of semi-circular thrust washers housed in recesses in the front and rear ends of both the cap and housing.

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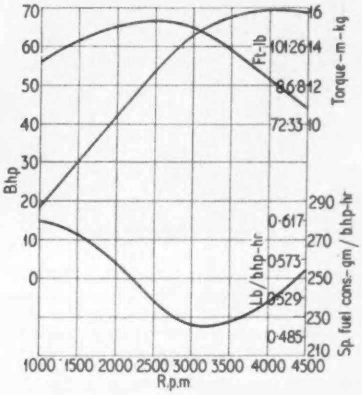
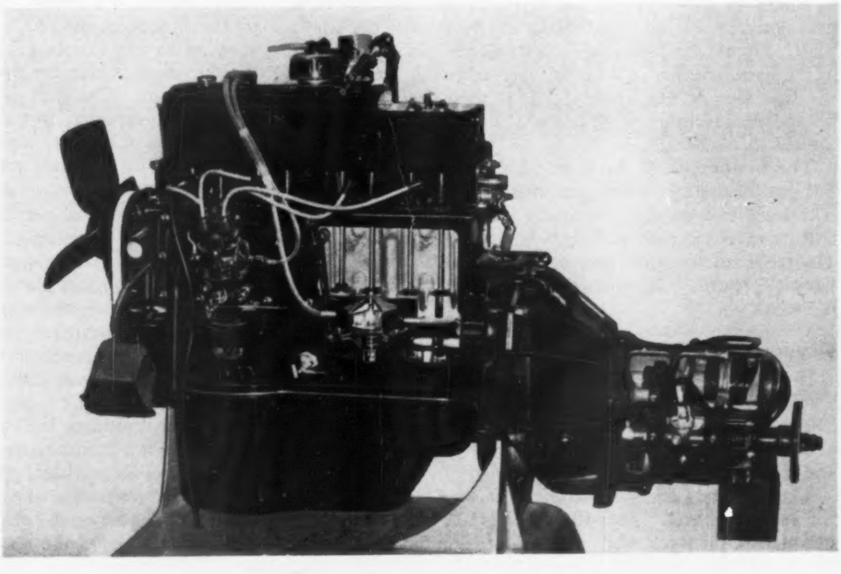
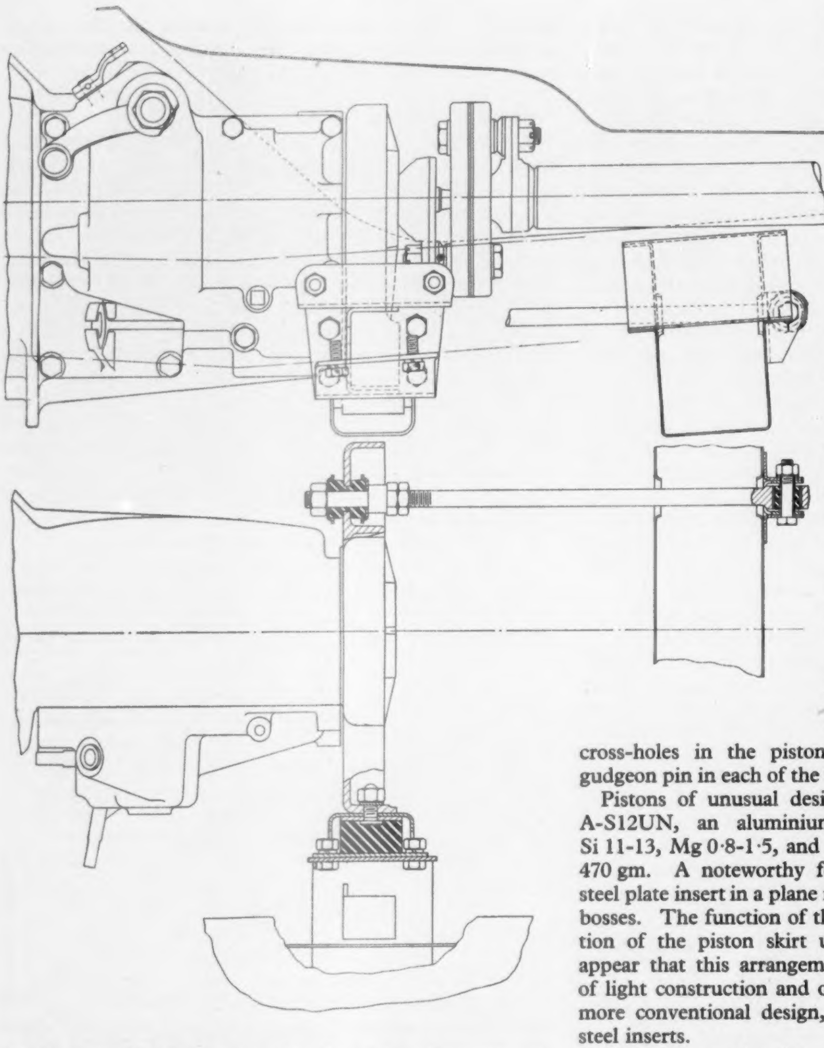


Engine performance curves obtained with the fan fitted, but without an air filter



Left-hand side of the engine and transmission assembly, sectioned for display. This side of the sump is shaped in such a way as to clear the drive for the oil pump and distributor units

Arrangement of the rear mountings for the engine and gearbox unit and of the tie rod with rubber end fittings



shaft houses the ball bearing for the 17 mm diameter end of the clutch shaft, and a felt seal in a steel housing is retained, in a hole in the centre of the flywheel, by a circular plate held down by the bolts that secure the flywheel to the crankshaft. Should any lubricant escape past this seal, it is trapped in the usual manner in a lipped countersink in the centre of the rear face of the flywheel. It is then drained through holes drilled from the front face so that it cannot contaminate the clutch plates.

The flywheel is of cast iron. Its overall dimensions are 284 mm diameter, without the ring gear, and 58 mm thick. The weight of the unit, complete with ring gear, is 37·5 lb and its mass moment of inertia is 0·831 kg-m². There are 116 teeth on the ring gear and they mesh with a pinion having 9 teeth. This gear, which is of XC48f carbon steel, is shrunk on.

Connecting rods and piston assemblies

H-section connecting rods of XC32f are employed. Their centre-to-centre length is 160 mm and they weigh 560 gm. The minimum cross sectional overall dimensions of the rods are: 13½ mm wide over the flanges by 22 mm deep, and the web thickness is 2½ mm.

The big ends are split at an angle of 72 deg relative to the axis of the rod. Two 10 mm diameter bolts of 35NC6h nickel chrome steel, with split pinned slotted nuts, secure each cap. There are two ribs round each cap; although this means that the caps have to be made separately from the rod, it ensures that they are adequately stiff to avoid distortion under load. This is an important feature so far as the avoidance of high local bearing pressures is concerned.

A 30 mm long phosphor bronze bush is pressed into the small end to carry the 24 mm outside diameter by 17 mm inside diameter gudgeon pin. This pin is of plain cylindrical section and is located axially by wire circlips in grooves in the ends of the cross-holes in the pistons. The bearing length of the gudgeon pin in each of the two cross-holes is 20 mm.

Pistons of unusual design are employed. They are of A-S12UN, an aluminium alloy containing Cu 0·5-1·3, Si 11-13, Mg 0·8-1·5, and Ni 0·5-1·3 per cent; each weighs 470 gm. A noteworthy feature is the incorporation of a steel plate insert in a plane normal to each of the gudgeon pin bosses. The function of these inserts is to minimize deflection of the piston skirt under thrust loading. It would appear that this arrangement allows the component to be of light construction and of greater rigidity than pistons of more conventional design, that is, those that do not have steel inserts.

Heat flow to the skirt is restricted by horizontal slots just below the ring belt, the skirt on the side opposite to the major thrust face being split. Transmission of the loads to the bosses is effected by means of integral aluminium alloy struts and the steel reinforcement plates. To support the flat crown, there are five ribs parallel to the axis of the gudgeon pin. The ends of the bosses are well clear of the bore of the cylinder, so thermal expansion of the relatively large masses of metal round the bosses in a direction parallel to the axis of the gudgeon pin is of little importance, so far as the fit of the piston in the bore is concerned.

All the rings are above the gudgeon pin. On each piston there are three compression rings, each having a face width of 2½ mm, and one scraper ring of the U-Flex type. The top ring is chromium plated and all three compression rings are of plain rectangular section, except for a slight taper on their faces to facilitate running in. An unusual feature of the ring arrangement is that the top land is only 4·6 mm wide between the ring groove and the crown.

Although U-Flex rings are normally produced by Thompson Products Inc., of the United States of America, Renault have a licence to manufacture them. The component is a channel section steel pressing. It is rendered extremely flexible by transverse slots about 1½ mm wide and 1 mm apart in the base of the channel and by slots a fraction of a millimetre wide in the flanges. There is one slot in each

The wet liners of the Renault 2·1 litre engine are assembled in pairs in the block and are easy to replace in service

flange for every two in the base, but the slots in one flange are offset relative to those in the other so that they break into the slots in the base alternately on each side.

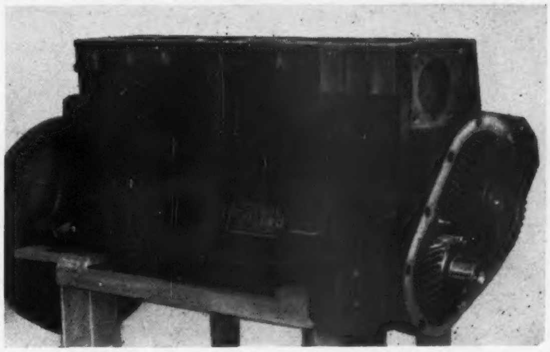
Timing drive and camshaft

Helical gears transmit the drive to the camshaft. Assembled in the following order on to the 32 mm diameter front extension of the crankshaft are the XC32f carbon steel timing drive gear, a dished oil thrower ring and a flanged sleeve that forms the boss of the pressed steel fan belt pulley. The whole assembly is retained by a special bolt, the head of which incorporates the dogs for the starter handle. There are two Woodruff keys in the crankshaft extension, one drives the timing gear and the other the pulley.

The oil sealing arrangement is unusual. An oil return groove is machined round the flanged sleeve that carries the fan belt pulley. This groove is taper-sided, being about 4 mm wide at the periphery and 3 mm wide at its root, and 1½ mm deep. It operates in a lipped sleeve brazed in a flanged aperture in the pressed steel timing drive cover. The lipped end is innermost and is enshrouded by the dished thrower ring. Its function, of course, is to prevent oil from running over the end of the sleeve into the oil return grooves. A headed peg is pressed through a hole in the front face of the timing drive cover; the head is innermost and the other end is tapered to form a pointer for use in conjunction with a mark on the pulley for timing purposes.

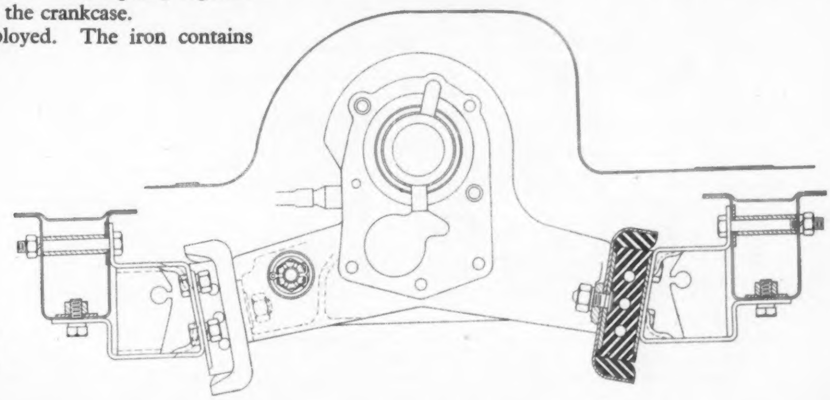
A plastics gear, with a moulded-in flanged bronze insert forming its hub, is employed for the half speed wheel. It is simply pressed on to the end of the camshaft and located by a key. A distance washer is interposed between the flanged end of the insert and the shoulder at the front bearing. This distance washer serves to hold the gear clear of the fillet between the front extension of the shaft and the shoulder. It also acts as a spacer to provide the clearance necessary for the accommodation of the thrust plate, also of bronze, that axially locates the shaft. This thrust plate, together with the front plate, is bolted to the crankcase.

A cast iron camshaft is employed. The iron contains

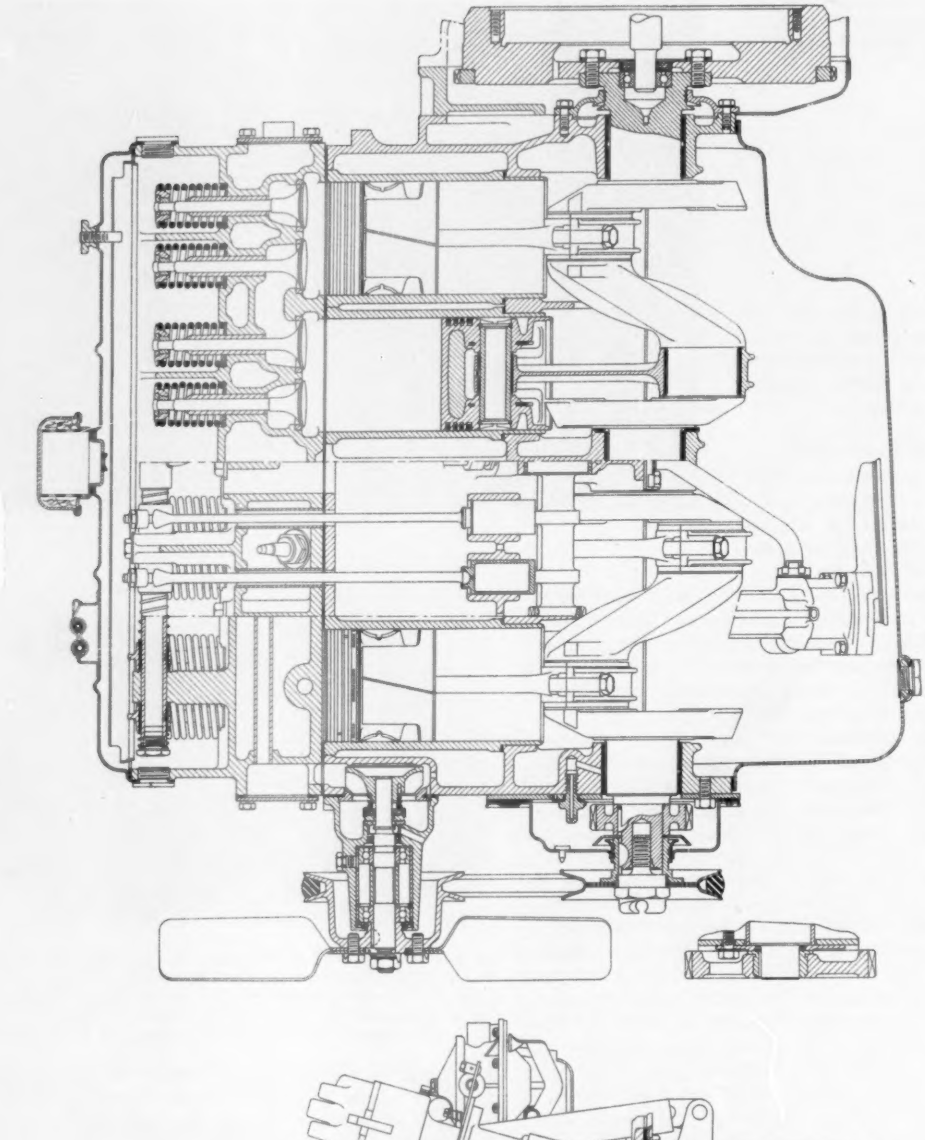


At the front, a pair of helical gears, the larger one being of plastics, transmits the drive from the crankshaft to the camshaft. The employment of a plastics gear enables silent running to be obtained without unduly close tolerances on the centre-to-centre spacing of the crankshaft and camshaft bearings and their housings in the crankcase

C 3·2-3·4, Si 1·5-2·0, Mn 0·7-1·0, P 0·15-0·22 and Mo 0·2-0·4 per cent; it is chilled at the cams to give a Rockwell hardness of 50-52 C. Between the cams, the shaft is 25 mm diameter. Vandervell, white metal lined, steel-backed bushes are employed; the front one is 48 mm inside diameter by 29 mm long, the intermediate one is 48 mm diameter by 24 mm long and the rear bearing is 40 mm by 18 mm long. A spiral gear to drive the oil pump and distributor is mach-



End elevation of the rear mountings of the engine and gearbox unit. The plan and side elevations are illustrated at the top of the opposite page



ARRANGEMENT OF THE RENAULT 2·1 LITRE ENGINE

An unconventional feature of the aluminium cylinder head is that the walls of the rocker box extend up to a level higher than the tops of the integral pedestals

ined on the shaft between the cams for numbers 1 and 2 cylinders, while between those for numbers 3 and 4 cylinders there is an eccentric to actuate the fuel pump.

Valve gear

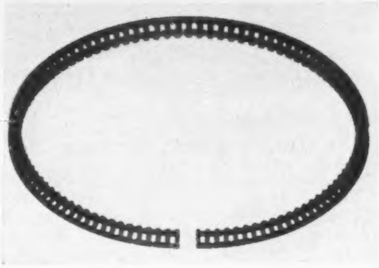
The tappets are unusual in that they are of cylindrical section, closed at both ends. They are formed by butt-welding together two case hardened mild steel thimbles. The main advantage of this type of tappet, by comparison with the more conventional piston type, is that it enables the push rods to be about 45 mm shorter and therefore reduces the weight of the reciprocating parts and increases the stiffness of the system. In addition, both ends of the tappets are stabilized so that these components can be of light construction. The tappets are 26 mm diameter and their wall thickness is 2 mm. They are housed in bosses in the base of the cylinder block casting, their effective bearing length being 40 mm.

The 7·5 mm diameter, solid push rods are of XC32f and the effective length of each of them is approximately 240 mm. Their spherical lower ends are case hardened to seat on the upper ends of the tappets, and their cupped ends are passed through tubes pressed in the aluminium alloy head and carry the ball ends of the screw type tappet adjusters in the ends of the rockers.

An unconventional feature of the rocker gear arrangement is that the pedestals are integral with the aluminium alloy head. The walls of the rocker chamber extend up to a level higher than the shaft, and transverse webs connect them to the pedestals to form an exceptionally rigid structure. These pedestals are line-bored from the ends of the rocker box, they are split radially to clamp round the shaft, and the front and rear of each is spot-faced where the rockers bear against it. After the boring operation, the holes in the ends of the rocker box are sealed by screwed-in plugs.

This arrangement has several advantages. One is that assembly is greatly simplified, since there are no bearing caps to be screwed down. Another is that the number of separate components to be manufactured is reduced. A third is that the pressed steel cover is small and the sides and end walls of the rocker box are thick and well supported by the webs, so that noise is reduced. Since the head is made of aluminium, the weight penalty is not great but, of course, more aluminium is used than would be the case if the sides of the rocker box were of conventional height and a deeper pressed steel cover were to be employed on this engine.

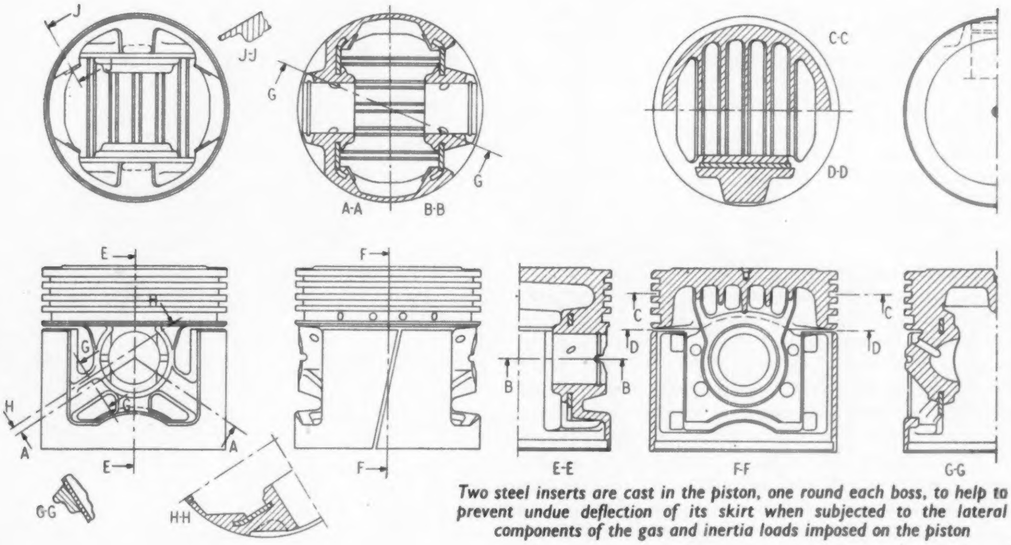
View looking into the rocker box, showing the arrangement of the pedestals, which are cast integrally with the cylinder head



Thompson U-Flex oil control rings are employed

Forged of 38C4h, steel rockers are employed. Each has a 22 mm long Clevite bush pressed into its bore. The shaft is 20 mm outside diameter by 14 mm inside diameter and its ends are sealed by screwed-in plugs. It is axially located by a screw inserted radially into the top of number 2 pedestal to register in a hole in the shaft. Coil springs constrain the rockers and pedestals in the usual manner, but washers are not interposed between the ends of the springs and the rockers. A sleeve adaptor for the lubrication connection is fitted round the centre of the shaft.

Details of the valves are given in the accompanying table.



Two steel inserts are cast in the piston, one round each boss, to help to prevent undue deflection of its skirt when subjected to the lateral components of the gas and inertia loads imposed on the piston

The inlet and exhaust guides are the same length and are, therefore, interchangeable. Their upper ends are chamfered, but their lower ends are square. The lower end of the inlet guide is flush with its housing, but that of the exhaust valve is about 2 mm inside the end of its housing. This arrangement has been adopted to ensure that the end of the exhaust valve guide does not become overheated by contact with the hot gases. If this precaution were not taken, there would be a danger of deterioration of the oil film between the end of the guide and the valve stem, and the resultant carbon formation might cause the valve to stick. The exhaust valve is unusual in that its neck is 1 mm larger in diameter than the stem. This undoubtedly is to ensure that the section is strong enough in the high temperature area, despite the fact that a relatively slender stem is employed. Another advantage of this valve neck arrangement is that only the stem has to be ground and the work hardened surface layers on the neck remain intact to give protection against burning and corrosion and to increase fatigue life.

Tulip type inlet valves and modified tulip type exhaust valves are employed because they are lighter than flat-headed valves and conform more readily to the seats. The inlet and exhaust valve seat inserts are of plain rectangular section except, of course, where they are chamfered to form the seating faces. Before the inserts are fitted, they are immersed in liquid air and the head is heated to 160 deg C.

VALVE DATA

	Inlet	Exhaust
Material	38 C 4h steel	Z30 CNWSD19 austenitic steel
Head diameter	38·5 mm	35 mm
Throat diameter	35 mm	32 mm
Stem diameter	8·970-8·955 mm	8·945-8·930 mm
Diametral clearance in guide	0·030-0·081 mm	0·055-0·106 mm
Seat angle	120 deg	
Face width on valve	4·6 mm	
Seat material	Cast iron	Austenitic steel
Spring material	XC 75 steel wire	
Spring length, free	61 mm	
Spring length, installed	51 mm	
Spring surge frequency	2,600 c/min	
Number of coils	6	
Coil outside diameter	32·8 mm	
Wire gauge	4·2 mm	
Spring retaining method	Split collets	
Valve lift	8·2 mm	
Rocker ratio	1·5:1	
Valve guide material	Cast iron	
Valve guide length	62 mm	
Valve guide inside and outside diameters	9 mm and 15 mm	
Valve opens	6 deg B.T.D.C.	46 deg B.B.D.C.
Valve closes	46 deg A.B.D.C.	6 deg A.T.D.C.
Ignition timing	5 deg B.T.D.C.	

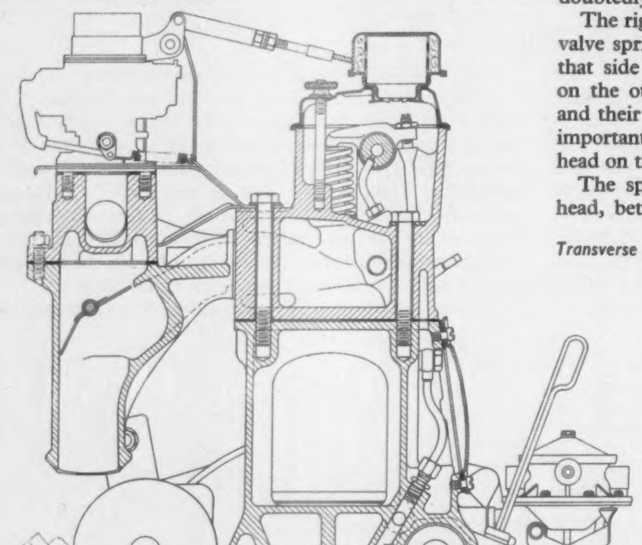
The material specifications quoted are those of the French standard PN R 971-01 (BNA448)

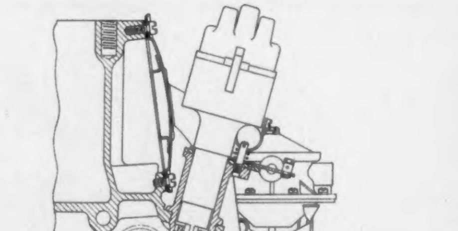
Cylinder head

An aluminium alloy, containing Cu 1·5, Si 2·25, Mg 0·1, Fe 1·0, Ni 1·5 and Ti 0·2 per cent, is employed for the cylinder head. The overall dimensions of the casting are 148 mm deep by 165 mm wide by 495 mm long. Its lower decking is 11 mm thick and the side walls and top of the casting are nearly all 6 mm thick. The unusually great depth, which is due to the fact that the rockers and the sides of the rocker box are cast integrally with the head, undoubtedly contributes much to the stiffness of the casting.

The right-hand wall of the rocker box is fairly close to the valve springs. This means that the holding down bolts on that side are not enclosed by the box; however, the bolts on the other side are. All the bolts are 12 mm diameter and their lengths do not differ greatly—this latter feature is important, since it helps to avoid uneven pulling down of the head on the block. A copper and asbestos gasket is fitted.

The sparking plugs are on the right hand side of the head, between the overhung base of the rocker box and a





Transverse sections of the engine, showing the oil pump and distributor drive and some details of the lubrication system

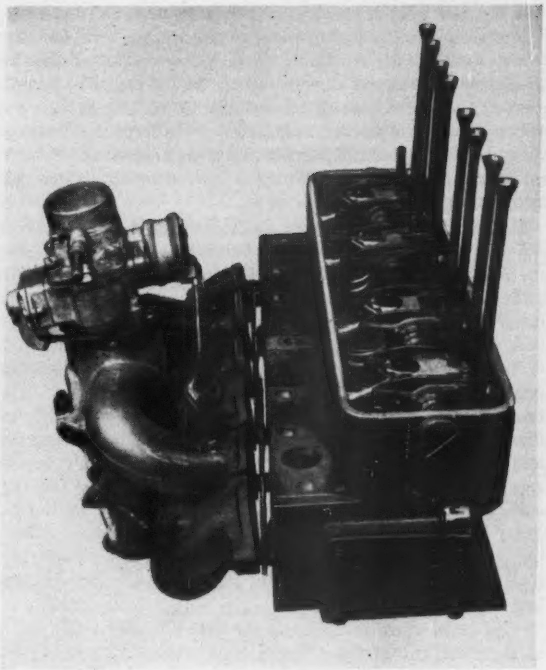
flange that forms an extension of the lower joint face. Steel tubes, with their ends swaged in holes in the base of the rocker box and the flange, house the upper ends of the push rods. Midway between the ends of the head, a large duct is cored vertically between the overhung portion of the box and the flange to form an oil drain into the tappet chest and thence to the sump.

Inverted-bath-tub type combustion chambers are incorporated. On the right-hand side of each there is a shoulder to give a squish effect as the piston comes up to top dead centre. The valves are in line and are set at an angle of 5 deg from the vertical, as viewed in end elevation. Although the edges of the ports, and even the valve heads, are well clear of the cylinder walls, the combustion chamber has had to be extended at the front and rear of each pair of valves to overhang the liner flanges. It is not clear whether this is necessary to ensure that there is ample room for the insertion of the seats, or if the extra space was provided in case it was needed for the incorporation of larger valves at a late stage in the development of the engine. The overhanging portion is lipped adjacent to the joint face, the lipped portion bearing on the end of the liner. This ensures that pressure is applied evenly round the cylinder; in addition, if the end of the flange were directly exposed to combustion it would tend to distort.

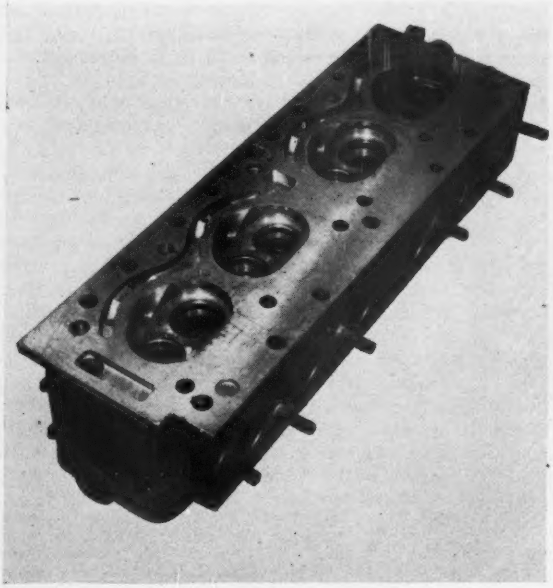
Carburettor, induction and exhaust systems

A Solex Autostarter carburettor, type PICBT, is employed. It has a 27 mm choke, and the jet sizes are as follows: main 130, slow running 50, slow running air bleed 120, automatic 165, starter 110, accelerator 50, emulsion tube 19, float needle valve 1·7 mm.

Both the aluminium alloy inlet manifold and the cast iron exhaust manifold are on the right-hand side of the cylinder head. The branch ports of the inlet manifold are swept down about 32 mm to the siamesed ports in the cylinder head. They are 33 mm inside diameter. Below them, the exhaust ports fall away from the head to the connection for the down pipe. This connection is 48 mm inside diameter. The two manifolds are bolted together and, when the engine is cold, a thermostatically controlled valve directs the exhaust gases into a jacket round the base of the riser. A 2 mm thick copper-and-asbestos washer is fitted at the junction between the inlet and exhaust manifolds.



Arrangement of the carburettor and inlet and exhaust manifolds



View of the joint face of the cylinder head, from which can be seen the layout of the combustion chambers and water passages

The down pipe goes to an elliptical section silencer under the body floor. This silencer is made from two flanged, dished pressings, welded together at their flanges. A steel plate, with a layer of insulating material on top of it, is secured to the body floor immediately over the silencer. The pipe from this silencer leads to another small silencer immediately in front of the back axle. Thence the exhaust is taken to the rear in the usual manner. Vehicles for export to countries with unsurfaced roads do not have the second silencer at the rear. Instead, the exhaust tail pipe is swept round to one side to discharge in front of the rear wheel. This improves the ground clearance at the rear end.

Water pump and cooling system

The water pump is driven at 1·1 times engine speed. As has already been mentioned, the driving pulley is a pressed steel component mounted on a flanged sleeve on the front end of the crankshaft. It is fabricated from two identical steel pressings brazed together, each forming one side of the V-channel. The included angle of the V is about 36 deg and the cross sectional dimensions of the V-belt are 17 mm wide by 11 mm deep. The driven pulley is an iron casting. It is keyed on to the front end of the pump spindle. The 347 mm diameter, four-bladed, pressed steel fan is spigoted and bolted to the driven pulley.

The pump rotor is unusual in that it is a brass pressing. It is pressed on to the 12½ mm diameter rear end of the spindle and is housed in a cell in the front end of the cylinder block casting. A flanged end-plate is spigoted into the front of this cell and is retained by the nose-piece casting, which carries the bearings and seal assembly. A joint washer is interposed between the front face of the cylinder block casting and the flanges of the front plate and nose-piece casting. A coil spring is spigoted over the front end of the boss of the pump rotor and forces a Cyclam seal against the end face of a flanged bronze sleeve spigoted into the bearing housing in the nose of the water pump assembly.

A thrower ring is machined integrally round the spindle; it operates in an annular space in the sleeve. Should any water pass the seal, it is flung off the thrower into the annular space and drains away through a hole drilled radially through the sleeve and the base of the casting. A felt ring in a groove in the bore of the sleeve immediately in front of the drainage space bears on the 16½ mm diameter portion of the spindle to ensure that the water flung off the thrower cannot get into the bearing assembly.

In front of this sleeve, and assembled on to the spindle in the following order, are: the rear ball bearing, a distance tube, the front ball bearing, a felt seal in a housing plate, and the pulley. The distance tube is, of course, between the inner races of the two bearings. The whole assembly, behind the seal, is carried in a large diameter sleeve housed in the nose of the casting. A circlip in the front end of the casting retains the seal, which bears on the boss of the pulley. The bearing and shaft assembly is retained by a nut on the 12 mm diameter threaded extension at the front end of the spindle, and location is effected by two circlips: one is in a groove round the shaft, behind the inner race of the rear bearing, and the other is in the housing tube, immediately behind the outer race of the front bearing. A grease nipple is screwed into the top of the nose-piece and the lubricant passes from it, through a hole in the sleeve, into the space between the two ball bearings.

The main water-outlet from the pump is into a cell, cored in the front end of the cylinder head, closed by a steel plate secured to the head by four set screws. From this cell, most of the water passes along a distributor tube, whence it is directed on to the sparking plug bosses and the exhaust valve seats. The remainder goes directly into the cylinder block, to cool the liners. Thence it passes through ducts into the head, and through the water outlet at the front end of the head on the shelf to the right of the rocker box. From the outlet, the water passes to the header tank of the fin and tube type radiator.

Oil pump and lubrication system

A gear-type oil pump is employed. It is bolted to the crankcase between numbers 1 and 2 cylinders and is above the oil level in the deep, pressed steel sump. The lower end of the gear chamber is closed by a casting which forms an inverted, dished pick-up. A gauze strainer is wired on to the casting, and it is about 10 mm above the base of the sump.

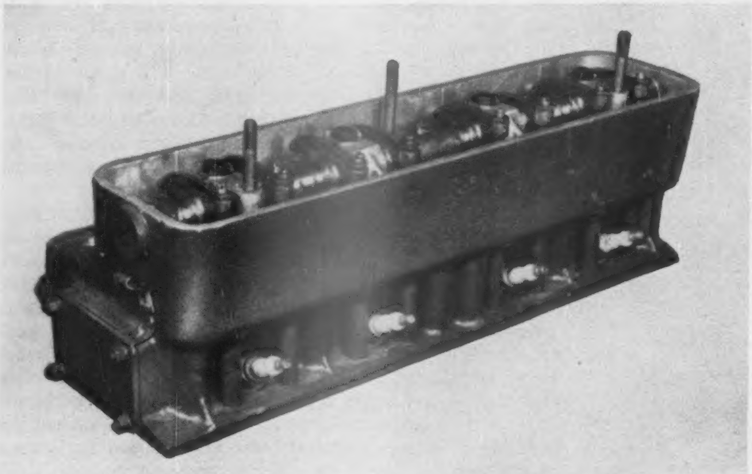
Both gears are 33 mm long and are of cast iron. The driven gear has a phosphor bronze bush pressed into it. Its short, 12 mm diameter spindle is pressed into a hole in the top of the housing, and there is a spiral groove round the spindle to spread lubricating oil over the bearing surface. An annular groove is machined in the bush to form a reservoir to retain a certain amount of oil when the sump is drained.

The spindle of the driving gear is also 12 mm diameter and is pressed on the lower end of its shaft. However, it is positively located by a screw in a hole drilled, from the lower end, half in the gear and half in the spindle. The end of the hole is peened over to lock the screw. Immediately above the gear, the spindle bears in a 25 mm long phosphor bronze bush pressed into a hole in the pump housing. Oil is fed into the upper end of this bush from a reservoir, which is formed in the top of the housing and filled by splash and drainage.

The upper end of the spindle is splined to receive a sleeve, on the periphery of which is machined the spiral gear that meshes with the driving gear on the camshaft. The lower end of this sleeve bears directly in its housing in the crankcase. Below it is a dowel sleeve to locate the pump body relative to the crankcase. The upper end of the spiral gear is slotted to receive the tongued spigot of the distributor drive. A turret casting, spigoted into a boss on the crankcase at a point immediately above the gear, carries the distributor. Interposed between the end of the turret casting and the gear is a flanged distance sleeve. The direction of rotation of the spiral gears is such that the axial thrust is taken by this distance sleeve.

A spring-loaded plunger type relief valve is incorporated in the pump casting. The head of the plunger is shouldered and the seating face is formed by a chamfer ground on the end of the small diameter portion. Thus, immediately the valve lifts, the oil pressure acts on the larger diameter portion, so the valve cannot seat again until the pressure has fallen substantially below that necessary to lift it initially. This ensures that the valve will not flutter. The by-passed oil goes through a radial hole just above the seat, into the centre of the plunger and thence axially through the spring and out through a pipe elbow, which directs it downwards to ensure that it is not splashed about by the rotating crankshaft.

The main gallery is 10 mm diameter and is drilled longitudinally in the base of the cylinder block. There are three 6 mm diameter drilled ducts between it and the main journal bearings. The upper end of the duct in the intermediate web is increased to 10 mm diameter and is joined by a hole of the same diameter leading from a pipe connection to the pump. A horizontal duct from this hole is drilled from the side of the crankcase and its end is tapped to receive the oil pressure gauge, which is screwed directly into it.



The holes for the rocker shaft are line-bored through an aperture in each end of the rocker box. These two apertures are then sealed with screwed-in plugs, one at each end

Screwed into the upper end of the 10 mm diameter portion of the connection between the gallery and the intermediate main journal bearing is a union for a pipe that takes the lubricant to the rocker gear. The other end of this pipe is connected to a banjo union in the top of the tappet chest, whence drilled ducts carry the lubricant through ducts in the upper portion of the cylinder block and the cylinder head to another pipe connection between the top of the head and the sleeve adaptor round the centre of the hollow rocker shaft.

From this adaptor the oil passes through a radial hole into the hollow rocker shaft and out through other radial holes to the rocker bearings. The oil return is through the push rod housings and also through a large cored duct, on the right-hand side of the head, to the tappet chest; thence it goes through small cored holes, between the tappet housings, to the crankcase and sump. A thimble fitting is screwed into the front wall of the crankcase and drilled to direct oil from the passage that feeds the front main journal bearing into the meshing point of the timing gears. The big ends are served in the usual way by drillings from the main journals. An unusual feature of the lubrication system is that the tappets are pressure lubricated, being served by holes drilled to draw oil from the main gallery.

Epoxide Resin Tools

Four Methods of Manufacture, Each for a Different Type of Application

EPOXIDE tooling is a development, about which Bakelite Ltd., of 12 Grosvenor Gardens, London S.W.1, have just compiled an information sheet based on their extensive experience. The advantages of using plastics and, in particular, of the polyester epoxide resins for the production of tools used in the engineering, foundry and sheet metal fabricating industries, are as follows. Plastics tools can be produced quickly to a high degree of accuracy directly from simple models or moulds made from wood, metal or plaster. Neither heat nor pressure is essential. Machining and hand finishing operations are eliminated and savings in both time and cost of production are made.

Polyester resins that cure without the application of either heat or pressure are being used to produce some types of jigs and fixtures, in the form of fibrous glass-reinforced laminates, but the shrinkage that occurs during cure limits the degree of accuracy that can be obtained. In addition, these resins are unsuitable for casting in bulk and their uses are therefore restricted.

The more recently introduced epoxide resins, which harden without the application of heat or pressure, are at present considerably more expensive than the polyester resins, but show negligible shrinkage during cure. Bakelite epoxide resins can be used either for laminating or for casting in bulk. The cured products are tough, hard wearing and very stable dimensionally, and their use for the production of tools is expanding rapidly. Duplicate models, checking and assembly fixtures, pantograph and copy milling models, foundry patterns, and core boxes, metal forming press tools for short runs and other similar tools based on epoxide resins are now being produced and used successfully.

Liquid epoxide resins are hardened or cured by chemically combining them with selected materials usually referred to as hardeners. These materials combine with epoxide resins to form an integral part of the hardened structure and have therefore a pronounced effect on the physical properties of the product. In addition, the hardener has a marked influence on the curing rate and handling characteristics of the resin-hardener mixture. The chemical reaction that takes place between epoxide resins and the hardeners is exothermic. Moreover, the rise in temperature, which is governed by the reactivity of the hardener used and the bulk of material involved, must be kept low in order to minimize the shrinkage caused by thermal contraction. When large bulks, which retain most of the heat generated, are involved, hardeners of low reactivity are employed. For smaller bulks, where part of the heat is lost, more vigorous hardeners are used, while in thin films and laminates, where almost all of the heat is lost, only the most vigorous hardeners are suitable.

One-stage gravity casting is the simplest method of production and is particularly suitable for the production of small, lightly stressed tools that are intricate in contour, for example, foundry patterns, core boxes, copy milling and pantograph models. This method can only be successfully used for castings up to a maximum thickness of approximately 6 in. Larger castings are made by the two-stage gravity casting method.

For large castings, where the one-stage gravity casting method is either uneconomic or impracticable because size precludes controlling the exothermic heat developed, a two-stage gravity casting method is used. A pre-cast core, containing a very high proportion of coarse filler, is faced to a thickness of between ⅜ and ¾ in with material similar to that used for one-stage gravity casting. The facing mixture should be standardized on resin R.18774, or R.18774/1, with hardener Q.18905 to a thickness of ⅜ in; alternatively, resin R.19019 with hardener Q.18988 can be used to a thickness of ¾ in. There is again a choice of hardener for the production of the core, the selection depending upon the size of the casting involved.

Large, lightly loaded jigs and fixtures, such as duplicate models, checking and assembly fixtures, and drill cages have to be of the lowest possible weight and have optimum stability and dimensional accuracy. These are best obtained, when practicable, by a laminated form of construction that includes woven glass cloth as reinforcement. The basic method of construction is to apply a surface coat of filled epoxide resin, which is reinforced by a laminate moulded without pressure to the required contour. The laminate is supported by a tubular or egg-crate type of structure.

Laminating combined with gravity casting is particularly recommended for producing highly stressed tools, such as those used for forming sheet metals. One- or two-stage gravity castings, in theory, have adequate mechanical strength for forming sheet metal and this has been confirmed in a few special cases or when tools have been used under carefully controlled conditions. For most practical purposes, however, their strength has proved to be inadequate, and tools produced by a combination of laminating and gravity casting, which include glass cloth reinforcement, are more durable. The inclusion of reinforcement eliminates failures due to localized or total fracture.

The method of manufacturing each component of a metal forming tool is in the first stage similar to that already described for producing the contoured laminates that are employed for lightly loaded jigs and fixtures. A surface coat of slate-powder-filled epoxide resin is reinforced by a glass cloth laminate, moulded without pressure to the required contour. The tool is completed by filling the cavity formed by the laminate with heavily filled epoxide.

FILLING BODYWORK SEAMS

Perdeck Solder Paints for Tinning Steel Panels

IN order to attain a desirable sleek appearance on modern production bodywork it is necessary for all seams and joints to be given a perfectly smooth, blended surface before the protective and decorative finishes are applied. These panel joints are usually filled with solder and before this can be done effectively the steel surfaces must be thoroughly tinned.

Imperfect tinning can be time-wasting in production and, since its consequences may not become obvious until after the vehicle has been in operation for a considerable period, damaging in service. In cases where the delayed effects of unsound tinning had led to deterioration of the filled joint, research revealed that a separate flux and either stick solders or other solder compounds had been used for tinning. When tinning by such methods, much of the flux is liable to be volatilized before the solder reaches melting temperature and slight surface greasiness due to handling or other causes may add to the fluxing difficulties which, basically, are the root cause of the trouble. Prior buffing of the metal cannot be depended upon to eradicate the problem, for the flux generally tends to contract on the metal surface in a somewhat similar manner to the way water contracts into drops on an oily surface. When the flame of a gas torch is directed to such imperfectly fluxed joints, the "dry" fluxed areas become oxidized, thereby adding to the tinning difficulties.

For car bodywork that will be exposed to the vagaries of the weather, it is essential that there are no minute pockets of porosity in the tinned surface or areas of corrosion will eventually be set up with disastrous results on the finished bodywork. Throughout the entire area treated, the tin must be continuously alloyed with or bonded to the surface of the steel panel. Any "bridging" of the tinning is inimical to a sound and weatherproof joint. A microscopic investigation of bridged tinning reveals small islands of so-called "homogeneous tinning" connected by small bridges of solder that are not actually bonded to the base metal. Such areas can sustain only slight tensile or shear forces and generally reveal themselves after persistent vibration in service has ruptured the attachments. Eventually, the solder fillet loosens and finally falls out.

These hazards are completely eliminated, it is claimed, by the use of Perdeck "EPATAM 3311" solder paint for tinning. The paint consists primarily of a pulverized solder held in stable suspension in a flux of a patented specification and can be applied by brush or by spray. The paint spreads easily, distributing the powdered solder evenly over the surfaces to be treated. No special preparation is necessary since the flux has powerful degreasing, spreading and wetting properties which effectively condition the surfaces for tinning.

The painted or sprayed area is then heated by any convenient means—a gas torch, for instance—to the usual soldering temperature until the solder in the paint flows over the surface. De-wetting will not occur as any grease or mild dirt will be lifted from the surfaces and will float on the tinning. Whilst still hot, the flux residues and the contaminations are removed by wiping with a dry cloth to leave a bright tinned surface. The coating is continuous and non-porous and a high measure of corrosion resistance is assured. The flux contains no free acid, although the residuals are slightly corrosive. These are either removed or neutralized in the usual alkaline wash which the body undergoes before priming.

This solder paint provides the most efficacious method of tinning but is also economical in production time and in material. The paint is water-soluble and can be diluted by the addition of tap water. It is stated that one pound of EPATAM 3311 paint when diluted with an equal volume of water will effectively tin an area of 50 ft^2 if it is applied by brush, and even more if the application is by spray gun.

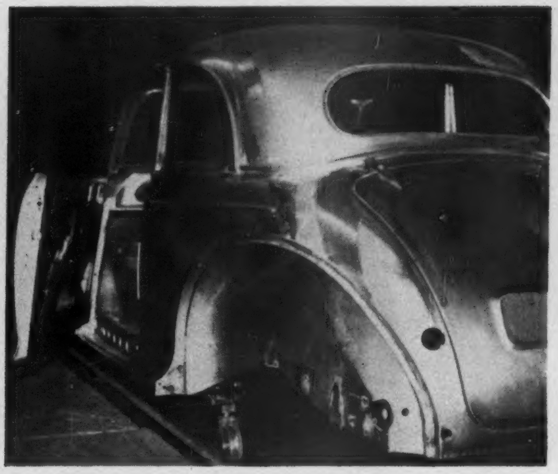
Tinning stainless steel

Conventional fluxes, or even strong phosphoric acid will not ensure the effective wetting of stainless steel and the tinning contracts in the familiar manner of water on an oily

Brush application of the solder paint to a seam-welded joint preparatory to tinning for subsequent filling of the joint with stick solder

Operators puddling stick solder into the bright-tinned joint. Open-flame gas torches are used and only normal soldering temperature is required

The solder-filled seam is disced off to leave a smoothly blended and run-out joint surface



A completed body shell "in the white" and ready to be moved off for priming and finishing

metal surface. This difficulty is overcome by means of a recently introduced version of EPATAM 3311 solder paint, designated PLF.73/11. It is used, undiluted, in the way already described and requires heating only to normal soldering temperature. Although specifically developed for stainless steels, it can be used equally well on all solderable metals and in the case of brass or copper can be slightly diluted with water to secure the utmost economy.

Another outstanding advantage of this special type of paint is its ability to tin metal surfaces heavily contaminated by rust, grease, or dirt. Heat higher than that normally required for soldering may be necessary on some surfaces and up to 350 deg C may be used for black mild steel.

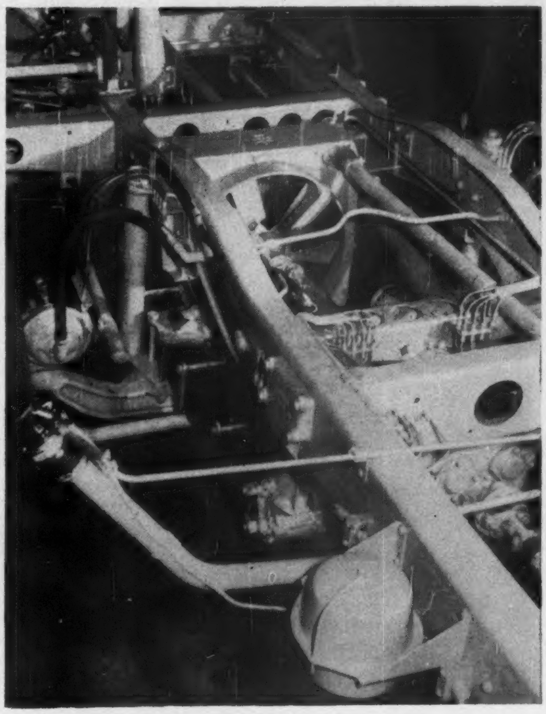
Each of these solder paints, the regular and the special versions, is available in several grades of varied specification to suit different metals. Three standard grades of the PLF.73/11 paint have 40/60 tin/lead, 60/40 tin/lead, and pure tin contents respectively. The research laboratory of the manufacturers, Perdeck Solder Products Ltd., Abbey Mills, Waltham Abbey, Essex, will undertake the investigation of specific tinning or soldering problems and advise on the selection and method of application of the paints.

Leyland Worldmaster Pressurized Cooling

A PRESSURIZED cooling system has been introduced, by Leyland Motors Ltd., for the home and export range of the Royal Tiger Worldmaster passenger chassis. This chassis, of course, is of the underfloor-engine type of layout and has proved to be particularly attractive for many of the export markets. In the near future, all the output of chassis of this type will incorporate the new cooling system.

The adoption of the new system has eliminated the need for the large header tank previously used on these models, but an expansion tank is needed to collect water ejected from the system as a result of the expansion of the coolant as its temperature increases. Another alteration that has been made is that the thermostat now opens at 165 deg F instead of 185 deg F.

With the new arrangement, a valve below the sealed filler cap opens when the pressure of the coolant exceeds 4 lb/in^2, the surplus coolant being taken by a pipe to the expansion tank mounted on the chassis frame. This tank has a capacity of approximately one-tenth of the total capacity of the cooling system. When the temperature of the engine coolant falls and the liquid therefore contracts, a second valve opens to allow the surplus coolant in the expansion tank to be syphoned back into the main system. This arrangement not only keeps the cooling system topped up, but also conserves the water and prevents loss of any anti-freeze mixture in it. The manufacturers state that tests have shown that the re-arrangement of the water circulation in the modified chassis results in a slightly lower consumption of engine lubricating oil, increases engine life and prevents loss of coolant. The new installation is shown on the right.



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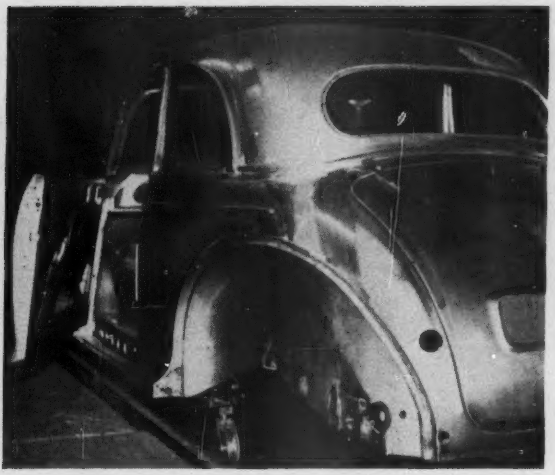

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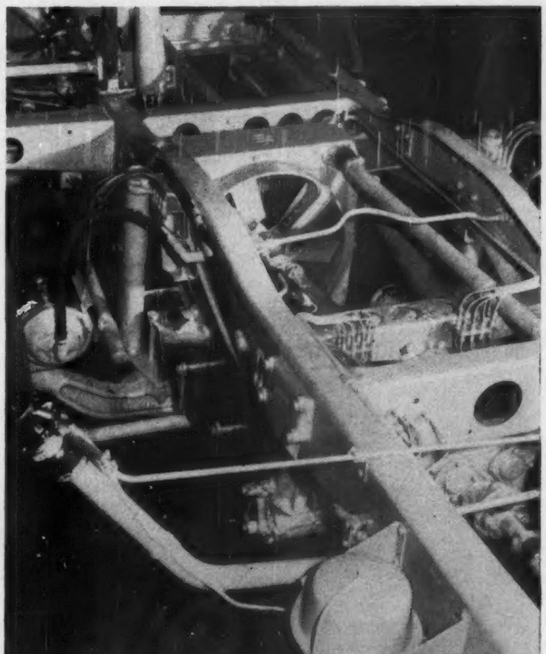
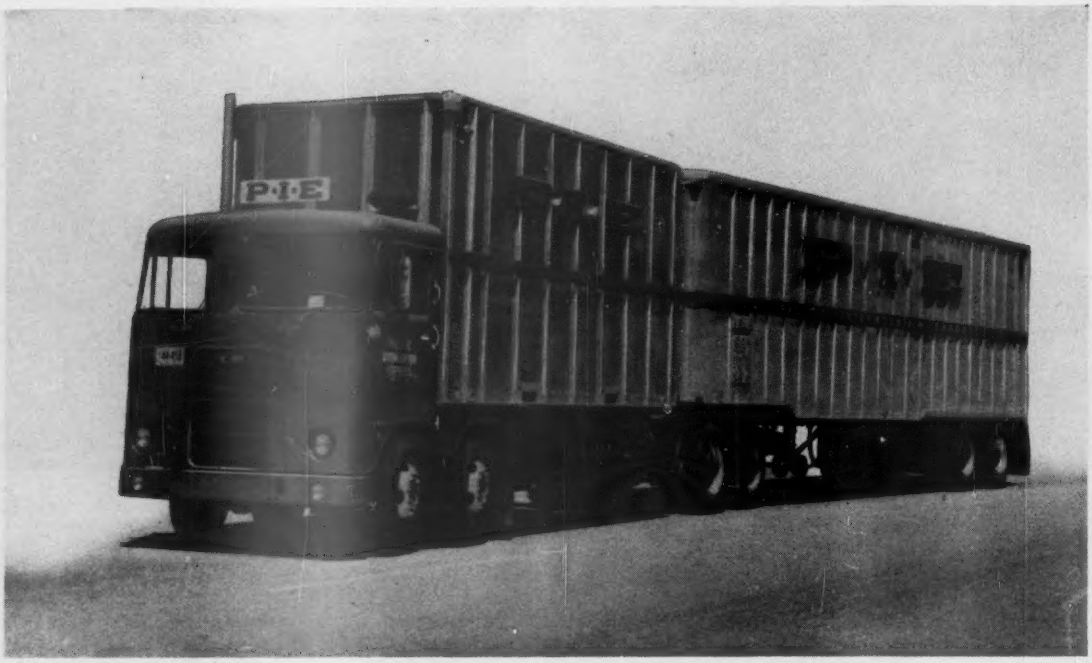




This truck-tractor with semi-trailer has been specially designed for service in Western U.S.A.

A New American High-Capacity Truck

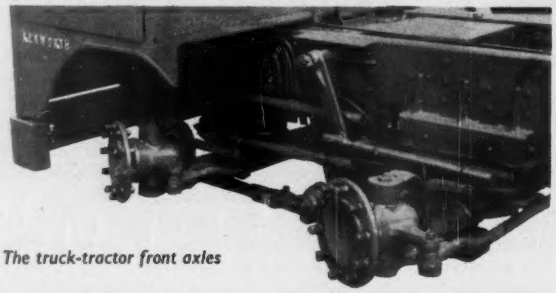
A Combined Truck and Tractor with Four Axles and Underfloor Engine

DESIGNERS of commercial vehicles in the United States have not one set of legal restrictions to contend with, but many. Each state is free to set up its own restrictions on speed, weight, length and other factors. In all the Western States, however, a maximum overall length of 60 ft for a truck and trailer is permitted and a special design of truck and trailer combination has grown up for use in this area.

One of the most interesting is a truck-tractor and trailer unit that has been developed by the Pacific Intermountain Express, of Oakland, California, long a pioneer in the evolution of special vehicles for use on its routes between Los Angeles, San Francisco and Denver. These vehicles have been designed for maximum payload capacity, both in pounds and in cubic feet, while keeping within the existing 60 ft overall and axle-load limits.

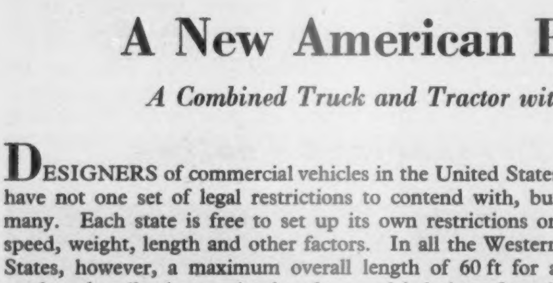
This truck-tractor unit, which is built by the Kenworth Motor Truck Corporation, of Seattle, is unique in several respects. First, while it is a tractor, in that it carries a "fifth wheel" and hauls a semi-trailer—an arrangement almost universal in heavy haulage in America—it also carries a cargo container. Next, it has two front axles, a design common enough in Great Britain, but almost unknown in America. Third, it has air-cushion springing, of the type described in the January 1956 issue of *Automobile Engineer* in connection with its pioneer use on the Greyhound "Scenicruiser" coach.

Finally, the engine is placed on its side under the frame, just behind the second front axle, much as it would be installed in an underfloor-engined bus.



The truck-tractor front axles

The rear axles are positioned by radius rods

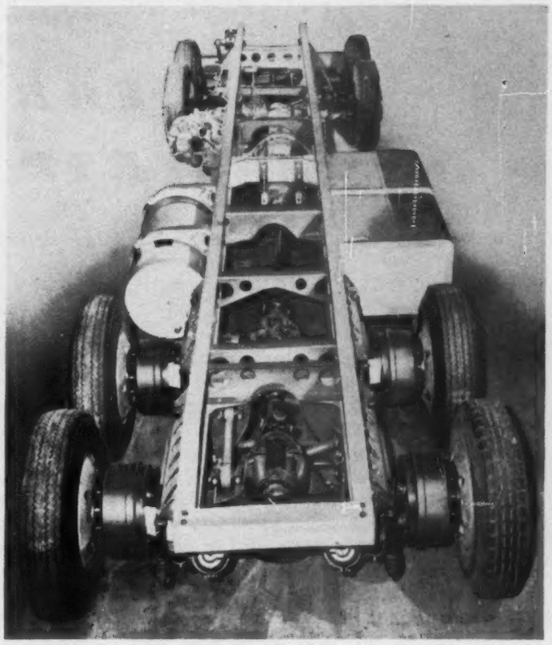


Truck-tractor unit

The truck-tractor unit is 31 ft long overall and has a wheelbase of 297 in, measured from the centre-line of the front bogie to the centre-line of the rear bogie. A 17 ft aluminium-alloy cargo box is mounted on its frame. Two

types of boxes are in use, one with a skin stressed to help carry the frame loads, the other separated from the frame and removable with its contents as a package.

The semi-trailer which is hauled by this tractor unit is 35 ft long and has a cargo body of the same length. With a cargo capacity of 1,025 ft^3 in the cargo box of the tractor, the total capacity of tractor and trailer is 3,300 ft^3. The weight of the bare truck-tractor is 16,330 lb, that of its cargo box is 2,550 lb, giving a tare weight for the track-tractor unit of just under $8\frac{1}{2}$ long tons.



The chassis for the truck-tractor

Engine

As the power unit for the truck-tractor, a Cummins model NHHT-600 engine is used. It has six cylinders, with a bore and stroke of $5\frac{1}{8} \times 6$ in respectively, and a displacement of 743 in^3. Its total dry weight, with all accessories, is 2,590 lb. It is fitted with an exhaust-driven turbo-blower and develops 250 b.h.p. at 2,100 r.p.m.

The engine is installed on its side, under the frame, immediately behind the trailing front axle. The radiator is mounted at the front end of the chassis in the conventional position and the cooling fan is electrically-driven. A fan motor, which is thermostatically controlled, operates on 110-volt D.C. current, which is supplied by the main engine-driven 110-volt A.C. alternator through a rectifier. The engine drives the vehicle through a conventional friction clutch and a ten-speed gearbox, all the gears of which are controlled through a single lever.

Axles

For the front axle the arrangement is generally similar to that used on several British lorries, except that a single, light semi-elliptic spring is fitted along each side under the axles. The main purpose of this spring is to position the axles and to absorb the braking torque, since the load is carried almost entirely by four separate air cushions, two directly over each axle. Regardless of the load, the frame height is kept constant by an automatic air valve which either admits or vents compressed air to or from the air cushions. The turning radius of the vehicle is 50 ft, which requires a $35\frac{1}{2}$ deg steering lock of the inner front wheel. Power-assisted steering has apparently not been found necessary.

The rear-axle suspension is similar to that of the front axles, except that the axles are positioned by radius rods. Two air cushions are fitted over each axle, with automatic frame-height control. Single tyres are fitted to all front wheels and dual tyres to the rear wheels; the tyres are tubeless and of the same size all round.

Zwickleen Edge-type Filter

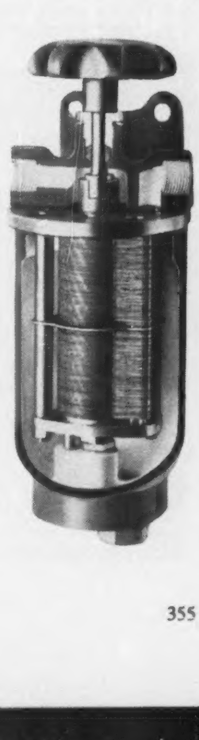
A NEW range of "self-cleaning" filters is now being produced by Zwicky Ltd., of Slough. Manufactured in six standard units with inlet sizes of from $\frac{1}{2}$ in to 2 in diameter, each is available with the strainer element discs spaced at 0·003 in, 0·006 in, or 0·010 in, equivalent to 200×200, 100×100 or 60×60 gauge mesh respectively. The smaller units, for piping of from $\frac{1}{2}$ in to 1 in bore, have bodies and sumps of light alloy and the connections are screwed either B.S.P. or U.N.F. Larger units are in cast iron and the connections are flanged. All are specified for a maximum working pressure of 50 lb/in^2 but are tested to 100 lb/in^2.

The strainer element comprises a stack of apertured steel discs interspaced by separators of a thickness defining the specified filtration gap between adjacent discs. Liquid flow is from the outside to the inside of the element, with any foreign matter being removed and held at the outer edges. A stack of steel scraper blades is mounted to one side of the element and engaged in the filtration gaps. Rotation of the element through 360 deg by means of the handle enables the scrapers to remove the whole of the accumulated dirt or debris, which then falls to the sump at the base of the casing.

Since the element is mounted in the casing and withdrawn with it, sump clearing is a more convenient and less messy operation than is usual. Strainer elements alone can be supplied for incorporation in a manufacturer's own products.

The filtration passage in the element, even at the closest spacing, has a clear area several times that of the inlet and outlet pipes. With the strainer gapped at 0·003 in, the capacity of the smallest unit is 155, 60, and 32 gal/hr for fluids of 50, 300, and 500 sec Redwood No. 1 viscosity respectively. In each case the pressure drop across the element is only $1\frac{1}{2}$ lb/in^2.

It is robustly constructed and cannot be damaged by a high pressure drop. The smallest unit weighs approximately 6 lb and has a sump chamber of 4 in diameter. Overall length, including the handle, is $8\frac{3}{4}$ in and only $1\frac{1}{8}$ in clearance is required to drop the chamber for withdrawal.



Zwickleen filter sectioned to show strainer element and scraper blades. The element is cleaned, without interruption of service, by a complete turn of the handle

COLD FORMING WIRE OR STRIP MATERIAL

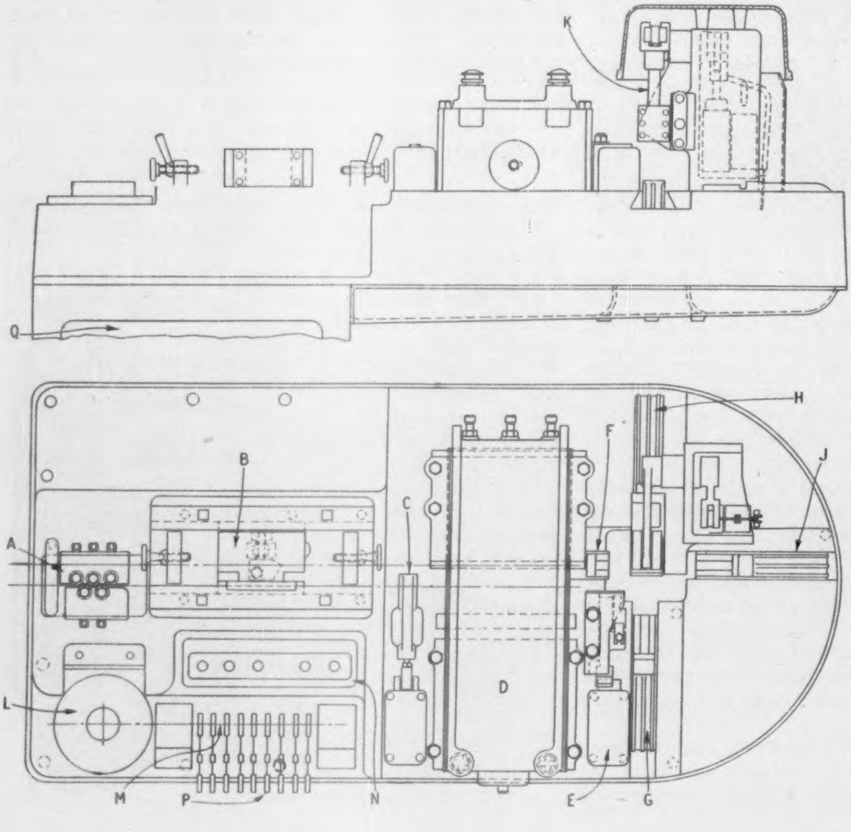
The New Heenan S $1\frac{1}{2}$ Hydraulically Operated Multiform Machine

MULTI-SLIDE presses for forming a virtually unlimited variety of shaped components directly from coiled stock are capable of very high rates of production. The camshaft speed, determining the cycle time and corresponding to the output rate, may be from 100 rev/min to 320 rev/min, according to the size and complexity of the component. With special tooling—forming two at a time and severing, feeding two wires or strips simultaneously, slitting a strip into two or more narrower strips, or pressing two or more blanks from a single strip—the normal single-part rate can be multiplied.

Hitherto, such multi-slide machines were mechanically operated. Press and slide movements were cam-actuated from an extensive shafting system around both sides and both ends of the machine. Box cams, angularly adjustable on their hubs and secured by pinch bolts, were employed. As the cams were relatively costly items and were not readily removable from their shafts, the practice was to fit maximum-stroke cams and to use them for all classes of work. Thus, in the case of some components, the working strokes of various slides were greater than was necessary.

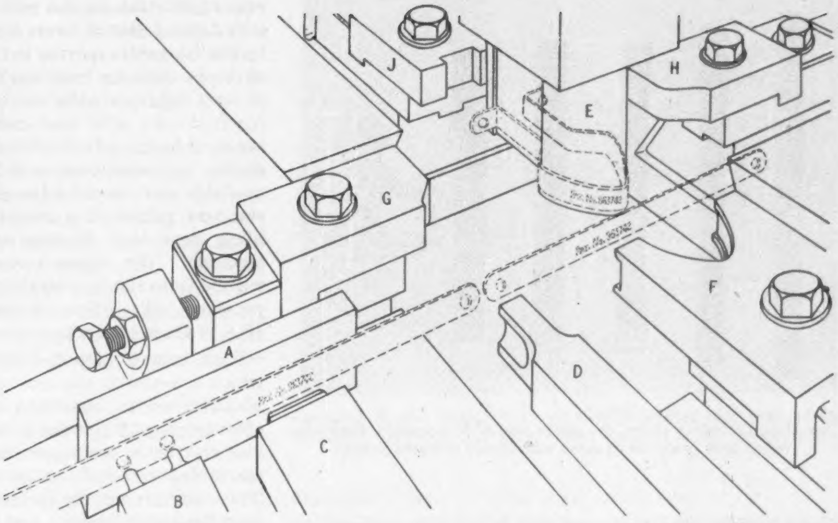
The high speed of operation was possible only by extensive overlapping of operations, and this demanded meticulous timing. Setting was effected by adjusting the angular position of the cams; an operation demanding the exercise of a high degree of skill and the expenditure of considerable time. Machines characterized by this combination of high output rate and relatively long setting time were, therefore, primarily of interest to manufacturers requiring exceptionally large quantities of certain components or to specialist firms supplying standard components to a wide market. Obviously, they were not economically suitable for the batch production of relatively small quantities of successively different components.

It was such considerations that led to the conception and design of the new hydraulically operated machine by



A quick-opening straightening rolls; B reciprocating feed gripper; C stationary gripper; D toggle-type, hydraulically operated press unit; E cut-off unit; F left-hand forming slide; G front forming slide; H rear forming slide; J right-hand forming slide; K vertical forming mandrel; L geared electric motor driving camshaft; M master camshaft; N control panel; P levers for manual setting movement of each slide; Q pedestal housing main driving motor, hydraulic pump, hydraulic accumulator and fluid reservoir

Arrangement in elevation and plan of the Heenan hydraulically operated S $1\frac{1}{2}$ Multiform machine



A *die set;* **B** *punches;* **C** *marking punch;* **D** *cut-off tool;* **E** *vertical forming mandrel;* **F** *front forming tool;* **G** *left-hand forming tool;* **H** *right-hand forming tool;* **J** *rear forming tool*

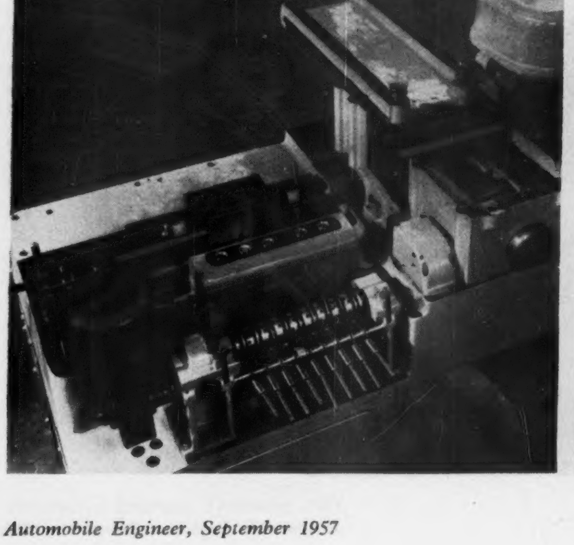
Schematic layout of press and form tools on strip-forming machine. The finished component is stripped vertically downwards from the vertical mandrel

Heenan & Froude Ltd., of Worcester, to supplement an existing wide range of mechanically operated machines produced by the company. The main objectives of the new design were the reduction of setting time and the simplification of setting so that it could be effected by semi-skilled labour. It is claimed that, for the majority of components, setting time has been reduced by 90 per cent. In actual practice it may take from two to four hours to reset a mechanical machine but the maximum time required on the hydraulic machine is thirty minutes.

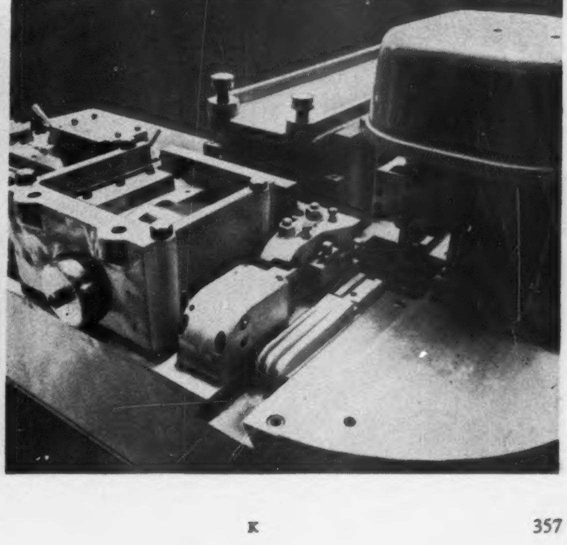
A conventional mechanical machine draws stock from a coil, straightens it, feeds it in accurate lengths, holds it, performs work on it with a horizontal press, and then progresses it to a forming station where four slides, operating horizontally, work against a vertical former around which the component is bent or folded. At some convenient stage the appropriate length of strip or the component blank is parted from the stock, and a vertical slide strips the component from the vertical former and discharges it through the table of the machine. The cams for actuating all these slides must be timed, together with the adjustment of the feed stroke and various other items, each time a machine is set to produce a different component. Moreover, the complete setting operation has to be repeated when subsequently the machine is required to produce the first component again. On the new machine the setting is made on a single small control camshaft, which can be readily dismounted from the machine as a unit and held in the tool store until again required.

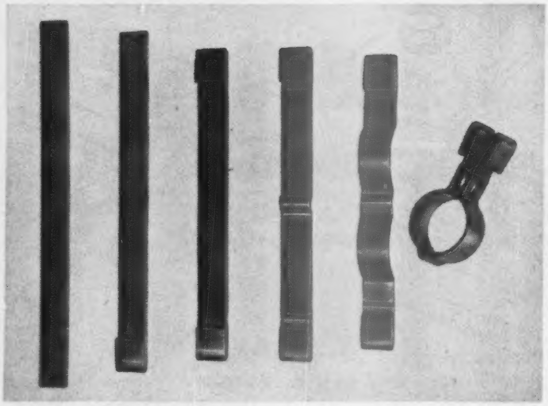
Dealing first with the layout of the new machine, it may be noted that it occupies approximately only 50 per cent of the floor space required by an equivalent mechanical machine. The overall dimensions are 5 ft 6 in long, 3 ft from front to rear, and 4 ft high. The omission of the surrounding shaft system and the actuation cams enables the setter to approach much closer to the machine centre and to observe the movement of the slides without being in any way endangered by revolving mechanism. Since the

The small master camshaft can be inched by push button and the slides can be moved manually when setting up the machine



View of the forming slides and the press. The press tie-bar is withdrawn on its slide mounting to give access to the toggle linkage





This heavy contact is turned out at the rate of 80 per min. Previously it had been produced on seven individually operated presses

whole working area of the machine is cantilevered from the pedestal, the setter can sit comfortably at chair height with his knees below the machine table. This constructional feature also leaves a clear space below the table for the placing and removal of work bins.

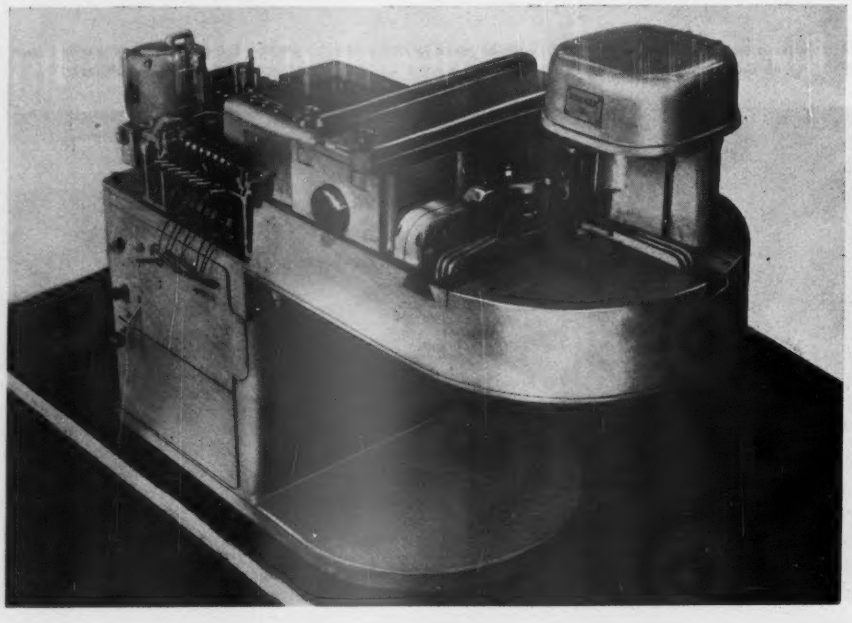
The system of hydraulic operation developed by Heenan & Froude Ltd. is relatively simple and gives a high degree of accuracy. Each slide has beneath it a hydraulic cylinder which is connected to a high-pressure fluid system. Control of the position of the cylinder is by means of a small servo valve requiring only a light mechanical movement to operate. Movement of the servo is reflected instantly and precisely in the associated slide cylinder.

There have been, in the past, other projects to operate slide machines hydraulically. In some instances control was by piston-type valves, and in others by solenoid-operated valves, but by neither method could the necessary precision be attained or maintained.

The servo valves on the Heenan machine are actuated by a small, light camshaft which is remotely sited in a convenient location on the table above the pedestal. Roller-ended cam-follower levers are connected to the servo valves by flexible cables moving in fairleads. The effective lengths of these cables are individually adjustable. Since the loading is very light—actually merely a few pounds pressure is required—the mild steel cams are only 0·125 in wide and are used in the soft condition. In the majority of cases, no doubt, the cams used will be of the standardized forms, available at a cost of a few shillings per set. However, the standard profile of a cam can be modified if desired by filing, even when the cam is mounted for operation on the machine. The slightest removal of metal from the cam will be reflected in a modified movement of the associated press or slide. Special cams can easily be sawn from 10 S.W.G. mild steel plate when required.

Each cam is mounted on a divided and screwed bush which is keyed to the cam spindle. It is clamped against a shoulder on the bush and is pinned to secure the timing after setting. Since the complete camshaft is producible at low cost, it is envisaged that the practice will be for an assembled camshaft to be retained for each component. The camshaft and the special tools for the component could then be stored together and be immediately available when next required for production. For rapid mounting and dismantling, the shaft runs in divided and hinged bearings. It is driven by a 380 V, 3-phase, 50 cycle, constant-speed electric motor having a geared output speed of 225 rev/min. The drive is transmitted to the camshaft by interchangeable pairs of gears to give the required camshaft speeds. Normally, these speeds range from 50 to 150 rev/min but higher speeds, up to 300 rev/min in suitable cases, can be arranged.

All tools—incidentally they are interchangeable with tools used on the counterpart mechanical machine—are designed so that they fit on the slides without any individual adjustment. When setting up to repeat a run on a particular component, therefore, it is merely necessary to fit the tools on the slides, mount the camshaft in position, and set up the stock reel, and the machine is ready to run. Any minor modification of a particular movement to the extent of a few thousandths of an inch that may be deemed necessary or desirable can be made whilst the machine is running by



On the hydraulic Multiform machine the worktable carrying the press and the forming slides is cantilevered from the pedestal to give free access. All driving mechanism is arranged below the table to ensure safety when setting and during operation

adjusting the effective length of the appropriate control cable from the cam follower to the servo valve. The result of any adjustment can be observed on the components dropped into the work bin. This is a considerable advantage, as on the mechanical type the machine must be stopped for any adjustment, with consequent loss of production time.

The fluid system is powered by a 7·5 h.p. electric motor driving a gear-type Dowty pump which draws fluid from a pedestal tank and charges a pneumatically loading accumulator. The capacity of the system is generously oversized and the requirements of the machine, involving rapid fluctuating deliveries of fluid, are easily met. Working pressure, normally arranged at 1,000 lb/in^2, is steplessly variable and may be up to 2,000 lb/in^2 when necessary for a specific job. Distribution is by way of a manifold under the machine table and direct to the power cylinders on the slides.

In the case of the horizontal press unit, it could not be expected in so small a machine that piercing and blanking pressures could be attained without some compressibility of the fluid occurring. This could result in the bursting through of the punches to the detriment of the dies. Accordingly, it was decided to use a toggle-actuated press unit operated by hydraulic cylinders. By this means the movement of the punches is precise and the spring factor is eliminated, thus ensuring that the press tools have a long working life. The capacity of the press unit is 10 tons.

Similarly, the movement of the feed slide is governed by a cam having a fixed stroke, so that the need to establish the correct pitch by trial and error does not arise. The stroke is determined hydraulically and, since for accuracy in the formed product length of stroke is critical, is precisely limited by easily adjusted mechanical dead stops.

When initially setting-up a new set of cams and tools it is possible to operate each slide manually, by means of a cable-attached tommy-bar inserted in a socket in the appropriate cam lever, in order to assess the travel required for the specific work to be performed. It is possible to start, stop, or inch the camshaft electrically from push buttons mounted on a control panel on the machine and accessible from either the front or the rear.

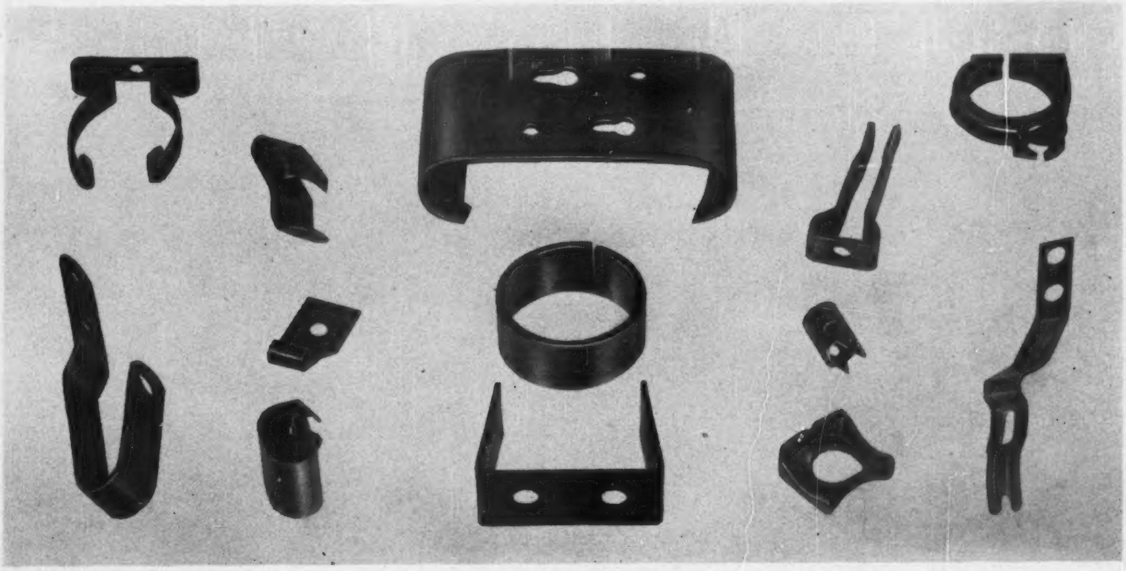
Examples of wire shapes in spring steel formed at high rates on the Multiform machine. Specimens shown are used in lighting equipment

For many jobs it will not be necessary for all slides to be operated. Any slides not required are left in a stationary retracted position by disconnecting the flexible lead from the cam follower to the servo valve at a convenient quick-connection coupling. Only the necessary stroke for the particular operation is made by any slide, full travel being used only when required. In combination, these two facilities enable the machine to be more closely timed, with consequent improvement in the production rate.

The pressure exerted on each slide is capable of stepless variation. Normally this pressure is individually adjusted to the value required to perform the specific operation. Thus, pressures generally are held to the essential minimum so that in the event of a jam-up, which conceivably could arise as the result of an unforeseen variation of stock width or gauge, the tools would not be damaged.

The machine can handle strip material in any metal in widths up to 1·5 in and with blank lengths up to 4·0 in. Its

Specimens typical of the wide variety of components that can be produced from strip material. The machine is equally versatile in the production of wire shapes



capacity for wire forming is wire of diameters up to 0·156 in with feed lengths up to 10·0 in. It is necessary to straighten wire in two planes, of course, and a suitable straightening unit is available for this purpose. All slides have a maximum travel of 2·0 in. and the press load is 10 tons.

Illustrations of merely a few of the components produced on the Multiform machine can convey only an inadequate impression of the versatility of the machine. The economies that can be effected by the use of multi-slide machines, whether of the mechanical or hydraulic type, are not generally realized. For example, the heavy electrical contact illustrated is made, complete with its two holes of different diameters, on a Heenan four-slide machine from $\frac{1}{2}$ in $\times$ 16 S.W.G. copper strip at the rate of 80 per minute. Previously it had been produced on seven presses with seven operators working progressively.

A prototype of the machine was first exhibited at the International Machine Tool Exhibition at Olympia, London, in 1956. Since then it has been intensively developed and full-scale tests have been conducted under actual production conditions. The production version of the machine, as described and illustrated, will be shown in operation at the 5th European Machine Tool Exhibition, to be held at Hanover, Germany, from 15th to 24th of September, 1957.

Spanish Motor Industry

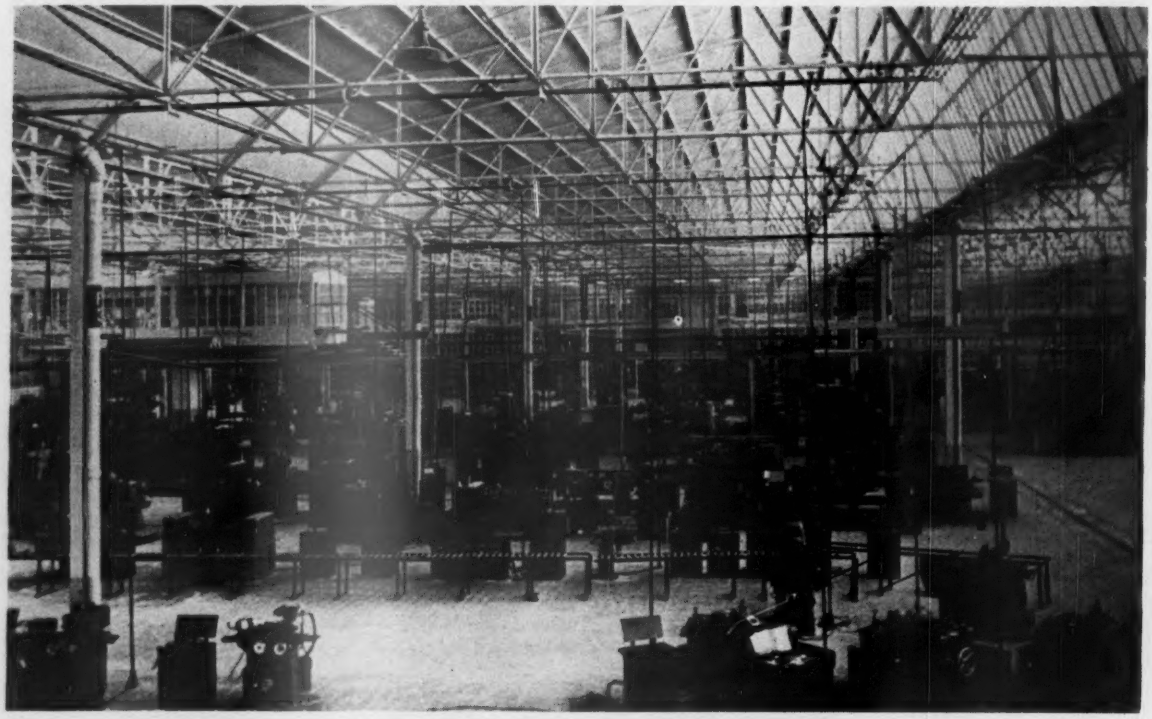
A New Commercial Vehicle Plant

IN 1948 there was virtually no automobile industry in Spain, but by the end of 1956 the country possessed (1) the E.N.A.S.A. plant in Madrid with 2,740 workers; (2) the E.N.A.S.A. plant at Barcelona with 3,600 workers and a planned production of 800 heavy diesel vehicles per annum, and (3) the S.E.A.T. plant in Barcelona with 1,000 workers and a planned yearly production of 10,000 cars based upon a Fiat model. The Spanish papers also report the formation of a company under French auspices for the ultimate yearly production of 6,000 midget cars, and another plant in Zaragoza for the production of American jeep-type vehicles.

Some details have recently become available concerning the E.N.A.S.A. plant, which is situated in the old suburb of Barajas on the outskirts of Madrid. At the end of 1946, the Instituto Nacional de Industria was entrusted with the creation of an undertaking for the manufacture of both medium and heavy trucks. As a result the company Empresa Nacional de Autocamionés S.A. (E.N.A.S.A.) was formed in the same year. The present capital of the undertaking is 2,100,000,000 pesetas. Approximately 180 acres of land was acquired at Barajas. The main manufacturing section has a floor area of 72,500 square yards, the apprentices' school 5,000 square yards, the foundry and forge 1,850 square yards, and the offices 12,860 square yards.

The plant has been designed for an ultimate yearly production of 3,000 Pegaso 110 h.p. diesel chassis suitable for 5/6 ton trucks, 750 touring cars with engines of 22 h.p. treasury rating, 300 crawler-type tractors with 70 h.p. Pegaso diesel engines, 1,000 wheel-type tractors with 40 h.p. engines, 1,000 Pegaso diesel engines of various types for naval, railroad and other applications, and 3,000 sets of electrical and injection equipment. At the end of 1956 1,260 major machine tools had been installed and a preliminary 200 vehicles had been produced.

Part of the machine shop in the new Madrid plant of E.N.A.S.A.



Automatic Plating Plant

Two Large Mechanized Lines Under Construction for the Fiat Mirafiori Works

WHERE very high rates of output in flow production are planned, it becomes of paramount importance to ensure the consistent quality of the work to be performed. Probably in no process is this more essential than in electroplating, in which many variable factors are involved. Increasingly it is being found that the necessary consistency, coupled with speed and economy, can be secured only by fully automatic machines equipped with adequate controls.

The Fiat organization points the example. Since 1950 it has installed seven Efco-Udylite automatic plating machines supplied by the Electro-Chemical Engineering Co. Ltd., of Sheerwater, Woking, Surrey. At present it has on order two further very large machines specifically equipped for cleaning, copper plating, bright nickel plating and chromium plating bumper bars. These are now being built and mechanically tested at Sheerwater. Of the seven machines at present in operation, six are at the Mirafiori works. When the two new machines are installed the Fiat concern will undoubtedly have the largest and most highly mechanized plating shop in Europe.

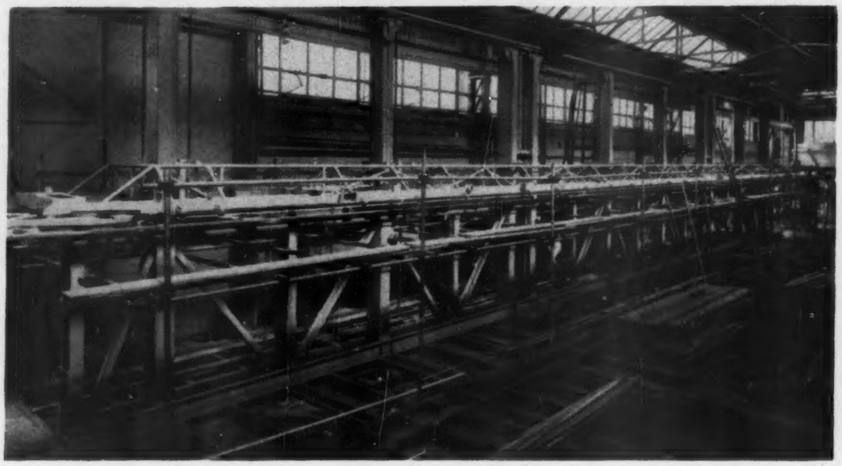
Both new machines are of the Efco-Udylite two-row, return type and are fully automatic in operation. The transfer mechanism comprises a lifting frame carrying the divided cathode tracks from which the plating racks are suspended. This frame, suspended on chains and balanced by counterweights hanging in the boxed central supporting columns, is raised and lowered by vertical hydraulic cylinders. Mounted on the frame is the pusher-type traversing mechanism consisting of hydraulic cylinders actuating horizontally disposed rocking levers which progress the racks. Hydraulic power is supplied by twin Vickers-Detroit pumps, manufactured in Britain by Stein and Atkinson Ltd., driven by electric motors. In the case of the copper-plating machine these motors are each rated at 15 h.p. An automatic safety device ensures that the lifting frame will be held, at any position, in the event of a chain breaking or the loss of hydraulic power.

At each traversing operation the racks are moved forward one stage. Racks in the plating tanks and other multi-stage tanks are traversed while remaining immersed. Others are lifted, progressed while suspended overhead, and then lowered into the next process tank in the sequence. The length of each tank is arranged to suit the relative immersion period required. Immersion times can be varied, of course, with a consequent alteration to the output obtained from the machine. Main plating tanks are each designed as a symmetrical loop at one end of the lines and can thus be built as extensions of the sections incorporating the transfer mechanism. This reduces the structural steelwork required and provides greater accessibility.

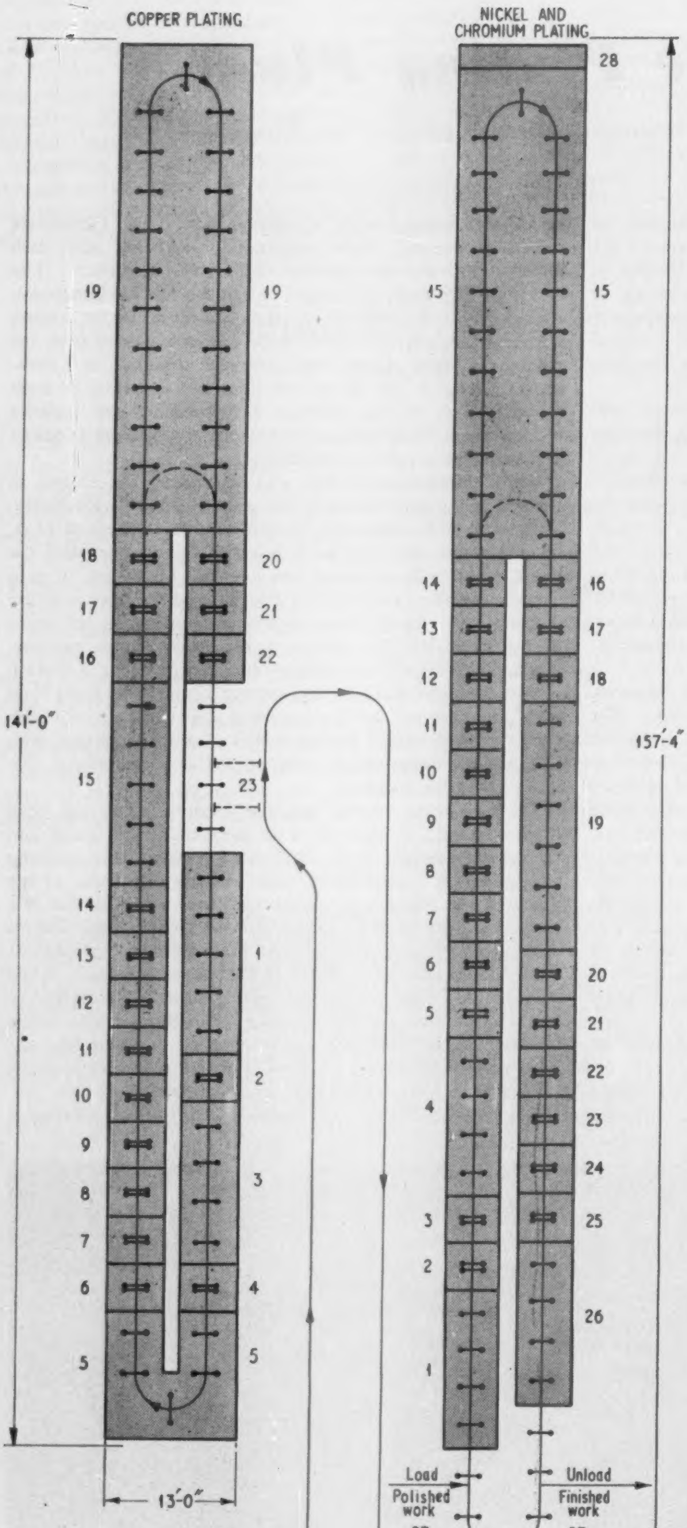
These machines for Fiat will be among the largest in Europe, being approximately 141 and 157 ft long respectively, with an overall width of 16 ft and height in excess of 18 ft. Process tanks are 5 ft 8 in wide and 6 ft 6 in deep and the main tanks will, in operation, contain 24,000 gal of acid copper solution and 25,000 gal of bright nickel solution respectively. Apart from loading and unloading the racks of work, no manual labour is required at the machine. Normally, the work is racked and unracked at a station remote from the machine and carried to and away from it on a shop conveyor. As the machines are of the return-track type they are loaded and unloaded at adjacent points and, usually, one operator can perform the two operations. No technical skill is required.

On the copper plating machine manual labour has been dispensed with by the use of an automatic rack loader and unloader. Located at the load/unload station, this handling equipment is synchronized with the track traverse of the machine and operates in conjunction with a parallel run of a shop conveyor bringing racks of unprocessed work from a convenient racking station. At each transfer operation a pair of these racks is delivered to the suspension hooks of the machine and a pair of racks of plated work is transferred to the hooks of the mating conveyor. On this conveyor they are taken to an automatic polishing plant. When returned from this operation the racks of polished work are manually loaded on the nickel and chromium plating machine.

Mechanized loading and unloading can effect substantial



The copper plating machine in course of erection at the Sheerwater works



LAYOUT OF EFCO-UDYLITE TWO-ROW, FULLY AUTOMATIC MACHINES FOR COPPER PLATING, BRIGHT NICKEL PLATING AND CHROMIUM PLATING FIAT BUMPER BARS

Copper-Plating Line

	Process	Immersion times min-sec	Tank lining
1	Anodic clean	5–20	Plain
2	Cold rinse	50	Plain
3	Anodic clean	3–50	Plain
4	Cold rinse	50	Plain
5	Cold rinse	5–20	P.V.C.
6	Acid dip	50	P.V.C.
7	Cold rinse	50	P.V.C.
8	Cold rinse	50	P.V.C.
9	Anodic clean	50	Plain
10	Cold rinse	50	Plain
11	Cold rinse	50	Plain
12	Acid dip	50	P.V.C.
13	Cold rinse	50	P.V.C.
14	Cold rinse	50	P.V.C.
15	Copper strike	5–20	P.V.C.
16	Cold rinse	50	P.V.C.
17	Cold rinse	50	P.V.C.
18	Acid dip	50	P.V.C.
19	Acid copper plate	32–20	P.V.C.
20	Cold rinse	50	P.V.C.
21	Cold rinse	50	P.V.C.
22	Hot rinse	50	Rust proof
23	Load/unload	3–20	—

Nickel- and Chromium-Plating Line

	Process	Immersion times min-sec	Tank lining
1	Emulsion clean	3–50	Rust proof
2	Hot spray	50	Rust proof
3	Cold rinse	50	Plain
4	Cathodic clean	3–50	Plain
5	Cold rinse	50	Plain
6	Anodic clean	50	Plain
7	Cold rinse	50	Plain
8	Cold rinse	50	Plain
9	Acid dip	50	P.V.C.
10	Cold rinse	50	P.V.C.
11	Cold rinse	50	P.V.C.
12	Copper flash	50	P.V.C.
13	Cold rinse	50	P.V.C.
14	Cold rinse	50	P.V.C.
15	Nickel plate	32–20	P.V.C.
16	Dragout	50	P.V.C.
17	Cold rinse	50	P.V.C.
18	Warm rinse	50	Rust proof
19	Chromium plate	6–50	P.V.C.
20	Dragout	50	P.V.C.
21	Cold rinse	50	Plain
22	Cold rinse	50	Plain
23	Neutralize	50	Plain
24	Cold rinse	50	Rust proof
25	Hot rinse	50	Rust proof
26	Cold air blow off	3–50	—
27	Load/unload	6–50	—
28	"Plating-out" section		

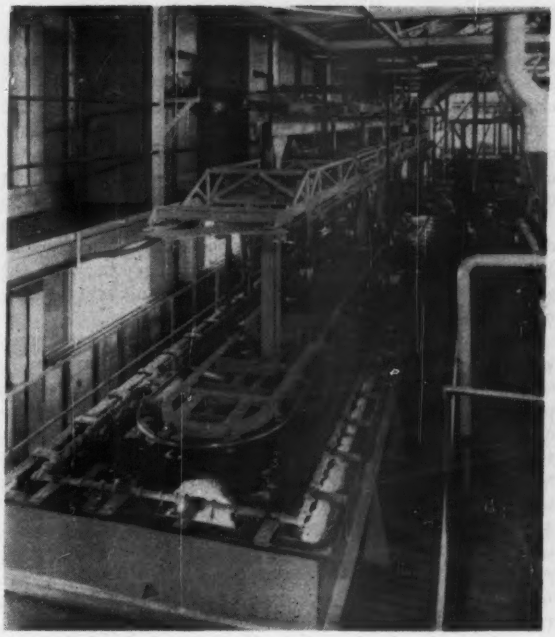
economies in maintenance. Damage to the insulation and the contact points of racks is liable to occur if, as a result of careless manual handling, racks are bumped or crashed together. With an automatic loader the racks cannot contact each other and consequently they have a longer useful life and reject-work arising from rack damage is less likely to occur.

All tanks for fuming solutions are equipped with lip extraction systems for the efficient side-to-side removal of fumes. Exhaust ducting is incorporated in the plant and operation is by means of a centrifugal fan. The tops of the tanks are also fitted with removable covers. These covers increase the effectiveness of the exhaust system and minimize heat loss, in addition to preventing dust or other foreign matter entering the solutions. Working conditions around the machines are excellent.

The process sequences reveal the care taken in cleaning and preparing the work before it enters the plating baths in order to obtain the necessary consistency of the finished product. Any carry-over of grease to the plating tanks would result in a grease film on the solution and the consequent production of rejects. On the copper plating sequence the work receives an anodic clean in an alkaline cleaner at 180-200 deg F at 50 a.s.f., a cold rinse, an anodic clean under the previously specified conditions, two cold rinses, and then an acid dip in a 25-50 per cent hydrochloric solution.

Next are two cold rinses, an anodic clean, two cold rinses, and a second acid dip in a 10-25 per cent hydrochloric solution. Two further cold rinses and it is given a copper strike in a cyanide solution at 140 deg F at 40 a.s.f. (This is necessary to protect the work when it enters the acid copper plating solution, otherwise it would, on immersion, dissolve out iron and contaminate the bath). After two more cold rinses and an acid dip in weak sulphuric to neutralize the copper strike, it is ready for the 32 min-20 sec immersion in the acid copper solution at 65-90 deg F at 40 a.s.f. After plating it receives two cold rinses and a hot rinse at 180-200 deg F before it is unloaded and conveyed to the polishing plant. All the cold rinse tanks are air-agitated.

Acid copper is selected for plating as it yields a deposit having a somewhat smoother surface than is obtained from cyanide copper. The plated work is easier to polish and shows better line removal. A continuous filtration system is provided for the acid copper plating solution and also for the bright nickel plating solution.



A representative example of an Efco-Udylite automatic plating machine in the plant of an Australian motor manufacturer

On the nickel- and chromium-plating machine the sequence for the copper-plated and polished work commences with a clean in a water-based emulsion at 130 deg F., a hot spray, a cold rinse, and a cathodic clean in an alkaline cleaner at 180-200 deg F at 50 a.s.f. There follows a cold rinse, an anodic clean, two cold rinses, and an acid dip in 5-10 per cent sulphuric. This acid bath is air agitated. Two more cold rinses and the work is then given a copper flash in a cyanide solution at 140 deg F at 40 a.s.f. to ensure that any exposure of the base metal at edges or corners as a consequence of the polishing and cleaning processes is

Typical automatic loader and unloader handling racks of pistons to and from a single-track machine at the works of a British engine builder

re-coated with copper.

Then, after two cold rinses it enters the bright nickel solution, at 140 deg F at 40 a.s.f. Immersion time is 32 min 20 sec, and the solution is continuously agitated by reciprocation of the cathode rods. At the looped end of this tank is the "plating-out" section. In this the solution is continuously cleaned by depositing any copper and iron impurities on dummy cathodes. By this means the production of relatively dark areas in recessed portions of the work is obviated.

Leaving the nickel plating tank, the work enters the dragout and then is given a cold rinse and a warm rinse at 160 deg F before it reaches the chromium plating tank for a 6 min 50 sec immersion in a 3·5 lb/gal chromic acid solution at 100 deg F at 120 a.s.f.

This bath is treated with Zero-mist, an Efco-Udylite additive which produces and maintains a thin foam blanket over the surface of the solution during operation. It completely suppresses chromium spray and mist and thus eliminates the health hazard to operating personnel. In this aspect it is approved by the factory inspectorate. Its use provides a number of advantages and economies in operation. Since the foam blanket reduces surface tension and acts as a wetting agent, it reduces dragout and thus the quantity of solution run to waste in rinse tanks is considerably reduced and effluent treatment can be less costly. Contamination of adjacent baths by chromium spray is completely prevented. It is quite stable and does not affect the chromium concentration of the bath. As the work is withdrawn through the foam blanket, only a thin film of solution remains on it, draining time is accelerated and carry-forward is reduced.

The cleaning sequence after chromium plating comprises dragout, two cold rinses, a neutralizing bath, cold rinse, hot rinse at 180-200 deg F., and a cold air blow-off.

The installation will process 160 bumper bars per hour. Two bumper bars, one front and one rear, are carried on each rack. They are suspended in a vertical plane at a suitable angle to facilitate draining and thus to minimize dragout. The dwell time on the traversing mechanism is arranged at 1·5 min and consequently forty pairs of racks are delivered for off-loading each hour.

The power supply for each machine is furnished by means of Westinghouse "Westalite" rectifiers converting the alternating current mains supply into low-voltage direct current. Developed specifically for plating operations, these oil-immersed rectifiers have a high efficiency and require no maintenance. Current to the plating baths is adjusted by a regulator, facilitating control of plating thickness and the rate of current consumption.

Automatic operation of each machine is controlled from a remotely sited, floor-mounted control panel incorporating contactors, controls for motorized valves, pump motors, fan motors, and voltmeters and ammeters for each electrolytic process tank. An adjustable time clock is fitted for controlling the variable time cycle. Rectifiers are controlled by push buttons on the panel.

ROAD VEHICLE LIGHTING

AN article entitled "Road Vehicle Lighting," by V. J. Jehu and A. J. Fisher, is published in the *D.S.I.R. Road Research Laboratory Note No. R.N./2934/VJJ/AJF*, January 1957. The following details of this article appear in the *M.I.R.A. Monthly Summary of Automobile Engineering Literature*, for June 1957.

After giving details of headlamp systems and auxiliary lamps at present in use, the paper describes a test procedure for identification of common faults in headlamp systems. Lamps should be rigidly mounted at the prescribed height from the ground. Lamp-glass flutes should be vertical. Lenses and, in older lamps, the gasket between the reflector and lens, should be undamaged, and the reflector surfaces should be bright and polished. Inadequate light output may be caused by a discharged battery, poor focusing, faulty connections or use of bulbs of high rated voltage in a low-voltage system.

Exceptionally poor aiming, incorrect connections or a faulty switch may hinder identification of the main driving beam, by which the lamps are aimed. Headlamps contributing to the driving beam should be aimed so that the brightest part of the beam is pointing straight ahead and horizontally, for block-lens units, and ½ deg down for other types of lamp. Single-beam, near-side headlamps which are illuminated for meeting other traffic should be deflected downwards 3-3½ deg and turned towards the nearside road verge. Auxiliary lamps should be dipped at least 3 deg unless used solely to augment the driving-lamp beam, in which case they should be aimed straight ahead; they should never be used to augment the dipped beam. Vehicles carrying heavy loads at night should be tested in a loaded condition; failing this, the lamps should be dipped 1-2 deg beyond the above settings. Details are given of the Road Vehicle Lighting Regulations, 1954, covering front lamps, side and tail lights, reversing lamps and reflectors. (M.S.R.)

CETANE NUMBERS

IN the *Journal of the Institute of Petroleum*, published in February 1957, is an article entitled "Cetane Numbers—Their Determination and Significance". Some brief notes on this article are given in the *M.I.R.A. Monthly Summary of Automobile Engineering Literature*, for June 1957.

The cetane number as a measure of diesel-fuel ignition quality is defined and briefly discussed; the fact is stressed that, in its determination, it is not essential to specify the design of the test engine used.

In the U.S.A., the A.S.T.M. uses a variant of the C.F.R. knock-testing engine fitted with a diesel-type cylinder head. Fuels are compared at a fixed ignition delay of 13 deg, and the compression ratio giving this delay is noted. The Institute of Petroleum, while accepting the A.S.T.M. method, recommends two alternative procedures: in Method A, the ignition delay of the test fuel is measured, and the corresponding cetane number is read off a rating curve obtained with reference fuels; Method B makes use of a relationship between ignition quality of a fuel and the point at which the engine using this fuel begins to misfire as its air supply is progressively throttled. The standard German method also employs air-intake throttling, the manifold depression being noted at a constant delay angle of 20 deg. With all these methods, it is generally convenient to use secondary reference fuels which have been carefully calibrated against the primaries, that is, cetane and α-methylnaphthalene.

Member laboratories of the I.P. Panel operate a correlation scheme through which two diesel fuel samples are rated every month by all participants. Another scheme provides for an exchange of ratings between the British and German panels. It is shown that, in spite of the differences of engine types, test methods and reference fuels, the ratings generally lie within one cetane number of the line of perfect correlation. A working group has been set up by the I.P. Panel to study ways of further improving test precision. (Z.M.)

FINE BORING

A New Heavy Duty Machine with Provision for Co-ordinate Setting

A FINE boring machine that incorporates many useful developments is shown in the accompanying illustration. It is designed and built by Henry Milnes Ltd., Bradford, Yorks, and Rockwell Machine Tool Co. Ltd., Welsh Harp, Edgware Road, London, N.W.2, are the sole selling agents for the United Kingdom. This machine has been specifically designed for the accurate generation of round, straight holes. It incorporates provision for co-ordinate work setting.

During operation the work remains stationary and the tool moves through the work carried by the massive boring head, which moves over inverted double vee slideways to give straight line motion. Because of its weight, the head is kept in close contact with the slides, so that accuracy of movement is always maintained. The work can be moved 15 in vertically and 30 in horizontally. The standard measuring attachment for both longitudinal and vertical movement consists of steel scales, verniers and measuring rod equipment. As extra equipment, precision scales with magnified optical verniers manufactured by Hilger and Watts can be supplied.

As the tool in the bar is always a fixed distance from the spindle bearings, it follows that any number of bores in the same straight line within reach of the bar will be bored under exactly the same conditions. They will not only be in line, but will also be exactly the same size, a most desirable feature when boring bearing houses for spindles.

Owing to the accuracy with which the work can be located, jigs are not necessarily required. In fact, most jobs can be bolted direct to the table, but simple fixtures are an advantage for repetition work and for castings of irregular shape. A standard set of boring bars will cover a wide variety of work, and tooling is, therefore, simple and inexpensive. The standard boring bars incorporate micro-bore tool tips, which have precision adjustment for depth of cut.

The head unit comprises a massive box-section casting weighing over 7 cwt. It has two internal cross ribs to carry intermediate support bearings for the spindle and driving shafts. The unit moves on automatically lubricated, inverted double vee slideways. This arrangement and the weight of the head give a backlash-free, straight line motion at all times. Keep plates are also fitted to prevent lift that might be caused by exceptionally heavy rough boring operations. The boring head has a power traverse of 19½ in. Provision is also made for hand feed, and in addition there is finger-tip operated quick traverse control for approach and withdrawal.

The boring spindle is 3½ in diameter × 27 in long. It weighs over ½ cwt and is fitted with a No. 50 taper. Hardened and ground all over, it runs on two 6 in diameter precision Timken bearings with a ball bearing at the tail end. There are 12 spindle speeds from 40 to 750 r.p.m. They are engaged by means of three levers on the headstock. A neutral position is also provided. This leaves the spindle free for hand rotation.

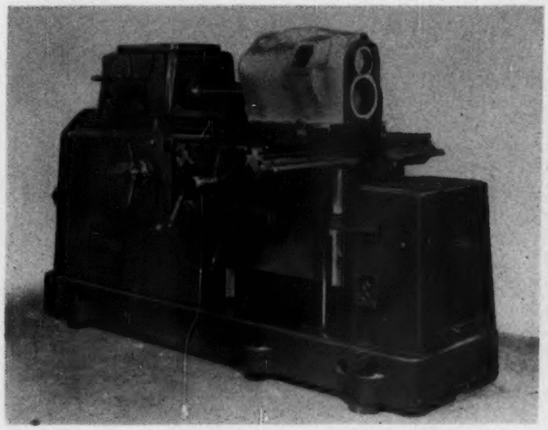
There are four power feeds available for each of the spindle speeds. They are: 0·0025, 0·005, 0·010 and 0·020 in per spindle revolution. A rapid traverse is also provided. To prevent damage in case of overrun, the feed drive incorporates a slipping clutch. The feed box has its own self-contained automatic lubricating system.

The machine table has a working surface of 48 in × 19½ in. It slides on two inverted vees, and is provided with two keep plates to prevent lifting. There are five tee slots, which are parallel to the vee slides. Horizontal traverse of the table, to a maximum of 30 in, is effected manually. The hand lever for traversing the table for setting purposes carries a dog clutch, which engages with a similar clutch on the table lead screw. There is a fixed index collar, graduated in increments of 0·001 in, to facilitate setting with the vernier scales or length rods.

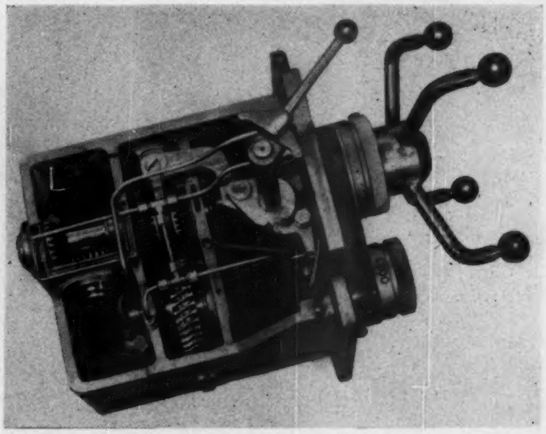
The table and knee unit has a maximum vertical travel of 15 in. Vertical traverse is effected by means of an elevating motor and the final drive to the elevating screw is by means of worm and wheel mounted on anti-friction bearings in a sealed and lubricated gearbox. Power is used for approximate setting, and the final setting is by means of a low-geared hand traverse lever. The elevating motor is controlled from two positions on the machine, one on the main switch panel and the other adjacent to the vernier scale. As a safety measure and for ease of setting, the motor operates only while the push buttons are being pressed, and to prevent accidental operation a "lift-up" flap covers each button.

A square indexing table is also available for use with this machine. This greatly increases the scope of the machine.

Milnes fine boring machine



The feed box has self-contained lubrication



PERFORMANCE ASSESSMENT OF OILS

A New Reflex Rating Technique

T. G. Bold and P. W. Harrison

THE performance assessment of oils is an art rather than a science, and it is still necessary to carry out mechanical testing to supplement chemical tests, despite the efforts made by chemical physicists to produce simpler tests for evaluating performance. Great strides have been made, however, by certain oil and additive manufacturers and they can, with their experience, forecast fairly accurately how a base oil of a certain type can best be additive treated to bring it to any required performance level to suit particular requirements. The final formulation, however, always requires a mechanical test of some nature in order to check that the end product is up to standard.

In order to compare oils it is essential to be able to assess the results of tests rather more specifically than by listing a few general remarks, and for this reason the appearance of components from all closely controlled oil performance tests are usually the subject of careful examination and dimensional measurement. Finally, a points award system or "merit rating" is applied for such factors as lacquer, sludge, carbon deposit or corrosion, etc. This paper describes a new method of rating oils for carbon and lacquer deposits.

Merit rating

Most merit systems are based on an arbitrary scale of 0-10 for each of the factors mentioned, 0 representing a component completely covered by deposits, and 10, components free from deposits. It will be appreciated that by using a system such as this, each assessment merit factor may be compared directly for different oils, and finally, if so required, one overall figure can be quoted as a summation of these factors representing a general merit of a particular lubricant. Considering a piston, detailed merit rating information is usually required of (a) skirt lacquer; (b) land lacquer; and (c) groove deposits.

Rating assessment

In order to assess pistons for rating purposes most laboratories use a form of graticule scale, or graduated turntable upon which the piston is mounted and which it is possible to lock in ten positions circumferentially; in this manner the piston skirt is divided into ten equal areas, in a vertical plane, see Fig. 1. By means of a vertical slide it is again possible to divide each area into a further ten areas horizontally; from this it is then possible to examine the component very critically, since each area will be one per cent of the total area under review. By taking account of colour variables it is possible to apply a colour factor correction for each area and arrive at one overall assessment figure. For a permanent record of the appearance of pistons, photographs taken at 180 deg intervals are usually provided, but these are not wholly free from distortion and cannot be used for obtaining a direct assessment.

Panoramic photography

A paper presented to the Society of Automotive Engineers and published in the August 1943 edition of the *Automobile Engineer* by members* of the Shell Development Company, described equipment designed to rotate a piston about the axis of a camera lens. The exposure is made through an aperture approximately a quarter of an inch wide, and in close proximity to the piston skirt, thus performing in reverse the function of a focal plane shutter. This method results in a panoramic photograph of the circumference of the piston, but the apparatus is complicated, costly, and requires the services of a trained photographer. Furthermore, the resulting photograph is not wholly free from distortion, and different sizes of pistons require additional

*Messrs. H. R. Luck, T. A. Rogers, A. G. Cattaneo.

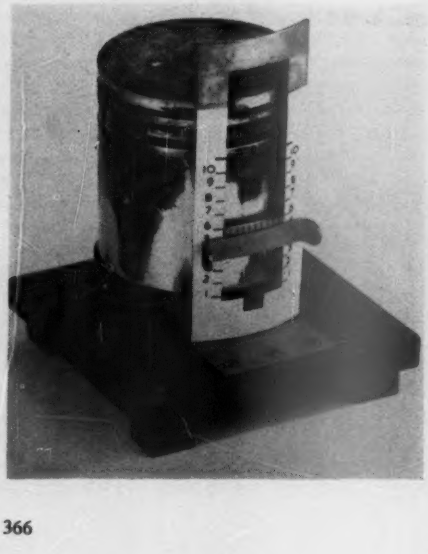


Fig. 1. Graticule scale and graduated turntable

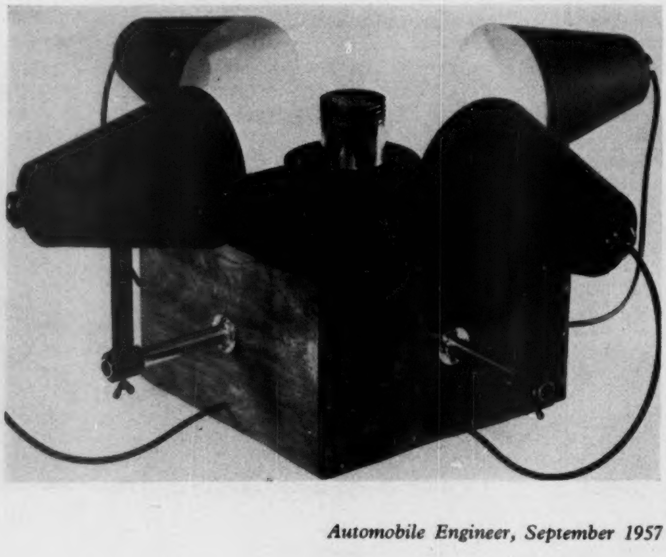


Fig. 2. Panoramic piston photography equipment

equipment. A panoramic photograph of component deposits, free from distortion, offers decided advantages, and methods of obtaining such a photograph have been investigated.

Reflex printing technique

A simpler method for producing a panoramic view of the piston skirt was required and the photographic processes loosely referred to as document copying were studied to determine whether one of them would be suitable for the purpose in mind. One of these processes is the reflex system whereby light is transmitted through the photographic paper and reflecting back from the object being copied, acts upon the emulsion of the reflex paper; for example, if a page of magazine requires to be reproduced, the emulsion side of a sheet of reflex paper is held in close contact with the page, and light passing through the paper is reflected back from the white areas but not from the black type. When the paper is developed a negative image appears, and in order to produce a positive, a similar procedure is followed using the negative, when a facsimile is obtained of the original magazine page.

A reflex paper with rather unusual properties is one known as Inverpos or Autopositive, which, when used in the manner described above, results in a direct positive image of the original, but it is a mirror image, that is, reversed from right to left. Exposure has to be made with high intensity light such as that given by Photoflood lamps and a yellow celluloid filter must be placed between the light source and object; unfiltered high intensity light must be prevented from reaching the paper which, however, may be quite safely handled in ordinary room lighting. This type of paper has been fogged in manufacture and relies upon the reflected light from the object causing a reversal effect upon the emulsion of the paper.

In order to produce an evenly exposed, panoramic view of a circular object it is, of course, necessary to rotate the specimen to ensure even illumination and consequently a simple and inexpensive turntable incorporating the lighting units was constructed, see Figs. 2 and 3. In Fig. 3, A is the reduction gear 400/1; B is the motor 1,400 r.p.m.; C is the process timer. The turntable makes approximately four revolutions per minute and four No. 2 Photoflood lamps enable an exposure of fifteen seconds to be employed. A pre-set timer is incorporated in the unit which, when a push button is pressed, causes current to be supplied to the motor and lamps, and, after the expired time interval automatically switches them off. Provision is made for adjustment of the lamp housings in order to provide uniform lighting for larger components and the turntable itself is 7 in in diameter. It can be raised or lowered to accommodate various sizes of pistons. To assist in assessing deposits more accurately, a graticule is incorporated on each print in the following manner. If the yellow filter, which has to be situated between the light source and the reflex paper, is cut to the circumference of the pistons being examined, it may be employed to hold the sensitive paper in position during exposure, Fig. 4, and if a graticule is inscribed upon the filter by means of a needle or other pointed object the resultant photograph, Fig. 6, will carry its own graticule, thus simplifying assessment still further.

In order to secure the sensitized paper in position during exposure, a piece of Sellotape placed over the gudgeon pin hole to hold the two ends of the filter graticule will maintain good contact between the piston skirt/paper/filter. It is important that both filter and paper be cut accurately to size in order that their ends just meet when held in position.

Standardization is essential to produce consistent results. It is desirable, therefore, to reproduce a photographic step wedge on each print, Fig. 6. This ensures that prints are

Fig. 3. Internal arrangement of equipment

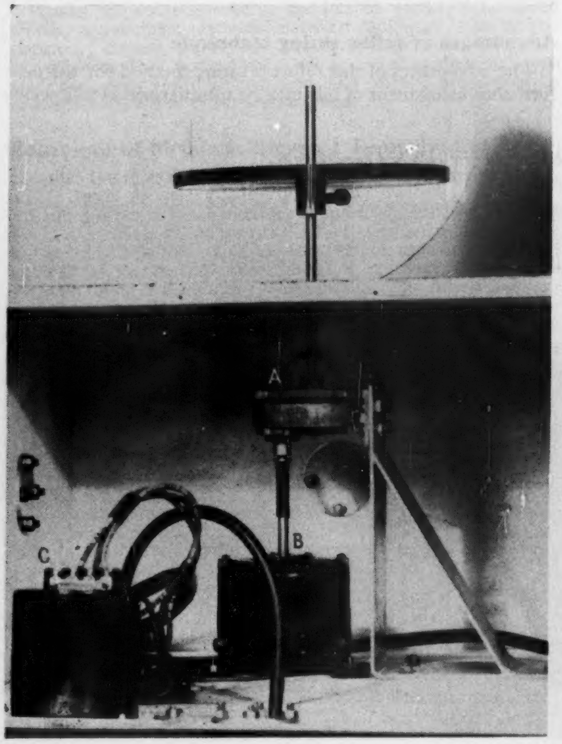
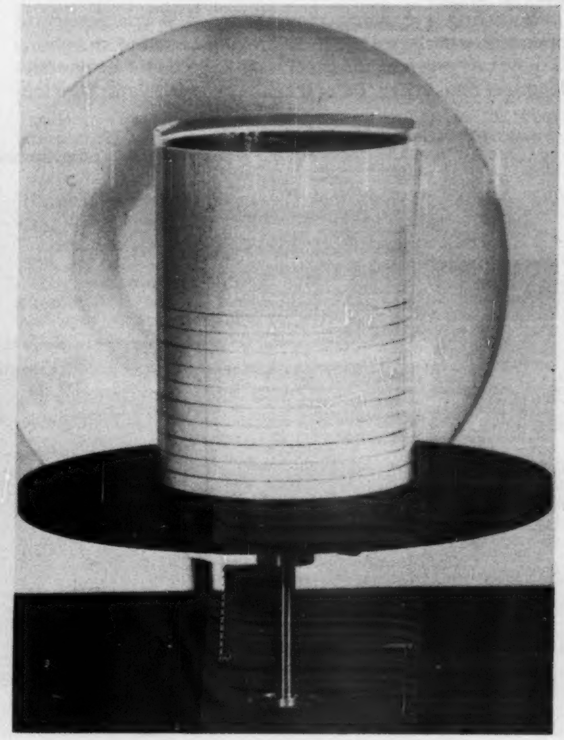


Fig. 4. Piston with reflex paper and graticule filter in position



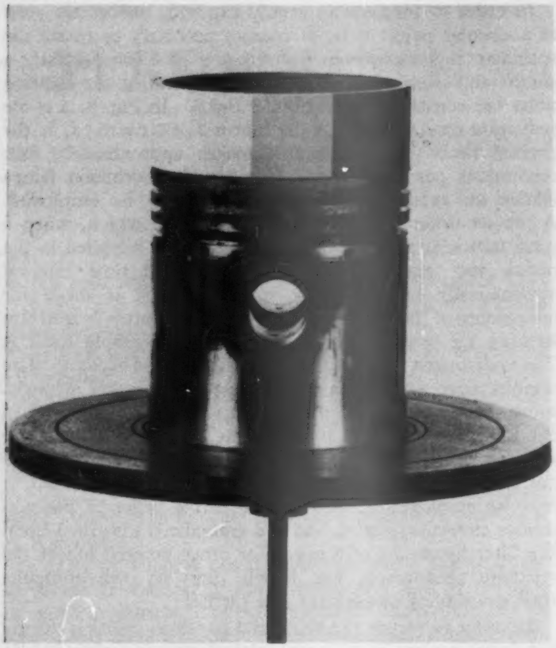


Fig. 5. Density strip attached to section of skirt in position

exposed and processed to a standard density. The step wedge should consist of no more than five steps of different densities, each step being approximately an inch square, one of which must be black and one white. The wedge may be affixed to a one inch section of a piston skirt which will also afford space for identification purposes. The skirt section is then placed upon the piston to be examined, see Fig. 5.

Processing is a simple matter since it is unnecessary to operate in a darkened room. Normal tungsten room lighting is quite safe provided the paper is not exposed for an excessive length of time to light other than the exposing light. Development is complete in 30-40 seconds in the developer recommended by the manufacturers; the print is then rinsed in running water for 5-6 seconds and then placed in the fixing bath where it should remain for a minimum of five minutes, during which time it should be frequently agitated. The print must then be washed in running water for at least ten minutes, when it may be allowed to dry naturally, but better prints are obtained if a print dryer is used, since this results in flat prints, free from curl and creases, and drying time is only about three minutes. If a short rinse in running water is used instead of the recommended washing time, it is quite possible to produce a finished print in about eight to nine minutes; insufficient washing, however, reduces the permanence of the image.

Interpretation of reflex print

It is of interest to compare Figs. 5 and 6. Fig. 5 is a photograph of one view of an 85 mm piston; Fig. 6 is a photograph of a reflex print of the same piston. The much clearer definition of the reflex print will be noted. (The print is a mirror image.) Light reflection as shown in the actual photograph is no problem with the reflex printing technique.

Each one per cent area is studied and assessed for surface area coverage and colour. By tabulation of each area and applying colour correction factors of 1 for black lacquer, 0·5 for brown lacquer, 0·25 for light lacquer and 0·125 for scratching, it is a five minutes task to obtain an overall rating figure for the piston skirt. Each step wedge should be used in relation to its own print, this obviates variations in sensitized paper. By using this method it has been found possible for two persons to repeat assessments within $\pm 0{\cdot}05$ of a rating on the skirt.

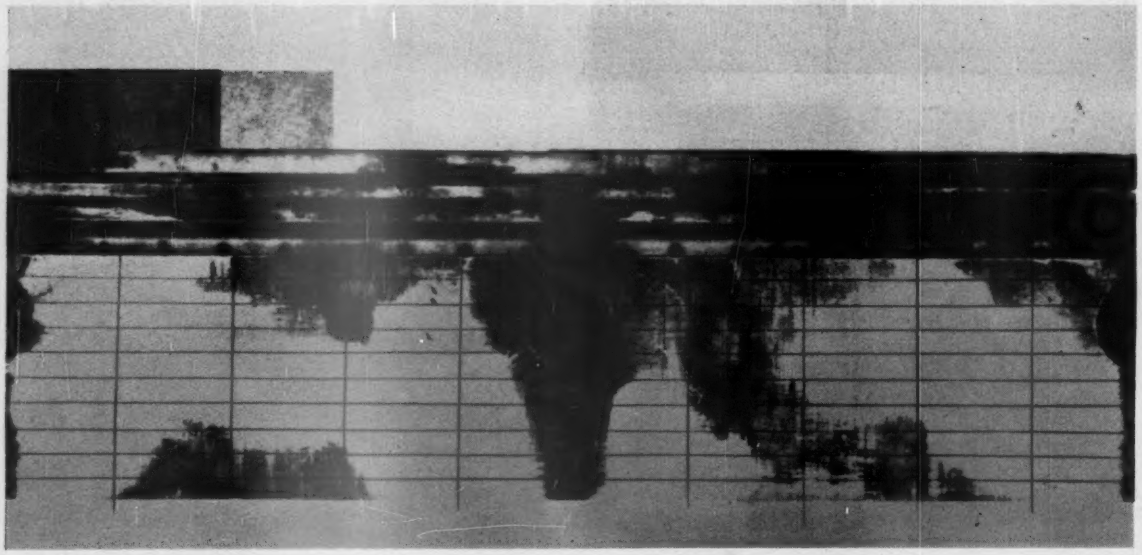
Scope of technique

This technique would appear to be applicable for carbon and lacquer ratings in any instance where it is possible for the sensitized paper to be held firmly in contact with the surface under investigation.

Advantages of reflex rating technique

The advantages of this reflex printing method for the performance assessment of oils may be summarized as follows:—

Fig. 6. Reflex print showing deposits, superimposed graticule and density strip



(1) The print can be used directly for assessment level determination.

(2) The equipment can be readily constructed and is simple to operate.

(3) The equipment in use does not require the services of a trained photographer.

(4) It is a very quick and a very cheap process—prints can be produced quickly for as little as sixpence or less.

(5) It gives a permanent direct record of conditions of components after testing, which may be used either in a report or easily filed for future reference, and which occupies very little space.

(6) No other method gives comparable results.

The authors, who are members of the Inspectorate of Fighting Vehicles, wish to acknowledge the approval given by the Ministry of Supply for the publication of this paper.

Recent Publications

Brief Reviews of Current Technical Books

Standards for the British Automobile Industry

London: Society of Motor Manufacturers and Traders Ltd., 148, Piccadilly, W.1. 1957. 8½×11. Approx. 200 pp. Price £4 4s.

For many years, the British automobile industry has applied recognized standards to its products. These standards have included those of the British Standards Institution, the Society of Motor Manufacturers and Traders, and the Society of Automobile Engineers. In 1955, a committee set up by the Council of the S.M.M.T. reviewed the standards and technical work of that Society and recommended that a Standards and Technical Board be formed. A number of committees and sub-committees were then set up to implement the policy of the Board and carry out the detail work of reviewing existing standards and preparing new ones when necessary. The handbook under review is the outcome of this work, which has been done in co-operation with not only the motor industry of Great Britain, but also other organizations, such as the British Standards Institution, and, through them, the International Organization for Standardization.

The intention of the Standards and Technical Board has been to include in this handbook the standards that are in common use by British manufacturers, throughout either the industry or important sections of it. Therefore, the work should provide designers and others with useful information concerning the standards that are directly applicable to their work. The book is published in loose-leaf form, so that it can be kept constantly up-to-date. A charge of one guinea per year is made for the service of maintaining the book up-to-date; subscribers' names are entered on a mailing list, and in that way are assured of receiving all amendments and additions.

Among the subjects covered are ferrous metals, non-ferrous metals, non-metallic materials, electrical equipment, lighting and signalling, trailers, engine and chassis, and general. There are 81 standards dealt with in the book as issued at present; seven more are nearly ready for inclusion, and work is proceeding on at least fourteen new or revised standards.

Behaviour of Metals at Elevated Temperatures

London: Iliffe and Sons Ltd., Dorset House, Stamford Street, S.E.1. 1957. 8¾×5½. 122 pp. Price 21s.

Since 1947, the Institution of Metallurgists has held annually a refresher course for its members. Each year, a particular theme is chosen, and papers giving the latest information on this theme are read by leading authorities. Starting this year, these papers are being made available to a wider public. The theme is a very important one—The Behaviour of Metals at Elevated Temperatures—this description covers the effect of temperatures from only slightly above normal up to the highest working limits.

In the introductory paper, N. P. Allen, Superintendent of the Metallurgy Division of the National Physical Laboratory, discusses the effects of high temperatures on the engineering properties of metals. These properties include stability of physical characteristics, elastic constants, coefficients of expansion, resistance to plastic deformation and fracture under stress, behaviour under fluctuating temperatures, and resistance to chemical attack. He also discusses the principles to be followed in developing alloys having good mechanical properties at high temperatures. These principles are illustrated and amplified in the last two papers.

The second paper, by G. E. Meikle, of the Metallurgy Department, Ministry of Supply, deals with the effects of temperatures up to 450 deg C, with particular reference to airframe structures and guided missiles. Among other things, he discusses kinetic heating. This is a comparatively new subject, which, as speeds increase, will become more important and probably will involve the introduction of a completely new range of materials into general use for these types of structures.

L. B. Pfeil, Director of The Mond Nickel Co. Ltd., deals with the effects of temperatures of 500 deg C upwards on non-ferrous metals, and discusses what is being done to provide improved materials for high-temperature service. Finally, W. E. Bardgett, Research Manager of United Steel Companies Ltd., deals with high temperature steels and shows how extended research is leading to a sounder basis for the selection of compositions for particular applications.

The papers in this series contain the latest information on a number of important subjects. A great deal of original material is included and it will prove invaluable not only to metallurgists, but also to engineers developing and designing equipment for high-temperature operation.

Guide to Broadcasting Stations 1957-1958

By the Staff of *Wireless World*

London: Iliffe and Sons Ltd., Dorset House, Stamford Street, S.E.1. 1957. 7¼×4¾. 80 pp. Price 2s. 6d.

Seasonal changes in the operating frequencies of some short-wave broadcasting stations, the use of additional frequencies by others, and the all-too-frequent variations in operating characteristics by many European long- and medium-wave transmitters make the annual revision of "Guide to Broadcasting Stations" an essential, if formidable task. Many hundreds of amendments have been made in preparing the material for this edition, and the information has been checked against measurements made at the B.B.C. Receiving Centre, at Tatsfield, Surrey.

The tabulated information, giving frequency, wave-length and power of over two thousand short-wave stations of the world, and some 750 long- and medium-wave transmitters in Europe, is listed geographically and in order of frequency. Incidentally, the present chaos among broadcasting stations in Europe can be judged from the fact that some 350 transmitters are operating on frequencies not allocated to them under the international plan drawn up at Copenhagen in 1948. These stations are italicized in the Guide. Other features include operating characteristics of v.h.f. sound broadcasting and television stations in Great Britain, Standard Time in all the countries mentioned in the book, international allocation of call signs and wave-length frequency conversion formulae.

Finishing Handbook and Directory 1957

Edited by I. S. Hallows, B.A.

London: Sawell Publications Ltd., 4, Ludgate Circus, E.C.4. 1957. 8¾×5½. 485 pp. Price 37s. 6d.

The seventh edition of this handbook and directory for finishing methods and materials has undergone a number of changes, but is in layout broadly similar to the previous one. It is divided into two parts: the first, which is printed on white paper, discusses in some detail the various finishing procedures, such as spray painting, stove enamelling, electro-plating, anodizing, galvanizing and vitreous enamelling, while the second, which is printed on buff paper and thumb-indexed, consists of classified lists both of British suppliers of finishing equipment, plant and materials, and also of jobbing firms.

The following sections have been added to the first part, which extends to 294 pages; Degreasing methods, including solvent degreasing, vapour degreasing, ultrasonic degreasing, emulsion cleaning, chemical cleaning and electrocleaning; Paint application methods, including aerosol spraying and electrostatic spraying; Treatment of plating wastes, and some notes on the legal position; and vitreous enamelling, including new production methods, new base metals, thinner coating developments, low firing enamels, chemical-resistant enamels, ceramic coatings, and colour improvements.

The second part, which is the directory of equipment, plant and materials used in the finishing field, of out-working firms and of trade and brand names, contains over 26,000 entries. This part of the book is, of course, completely revised every year.

Selectroshift and Autoselectric Transmissions

Latest Developments in the Application of the Smiths Magnetic Particle Coupling to Semi- and Fully Automatic Transmission Systems

SINCE the Smiths semi-automatic and fully automatic transmission systems were first described, in the May 1954, issue of *Automobile Engineer*, considerable development work has been carried out on them and they are now ready for production on a large scale. The changes that have been made to the semi-automatic system, which is now termed the Selectroshift unit, mainly concern the electric control circuits, but the coupling has also been redesigned to incorporate a sprung centre. As in conventional clutches, the sprung centre is employed to damp out vibrations that might cause transmission rattle when the vehicle is coasting between the drive and overrun conditions. With the magnetic coupling, the sprung centre is not required to absorb shock due to fierce engagement since this is avoided by the smooth take-up of the coupling, which is modulated by the automatic control. In the fully automatic system, now named the Autoselectric transmission, the coupling design has been modified to reduce the inertia of the rotating components as well as to incorporate a sprung centre. Changes have also been made to the electric control system, but the gearbox is virtually unaltered.

The fundamental principles of the unit and the early history of its development were described fully in the previous article. Both the semi- and the fully automatic systems are based essentially on a magnetic particle coupling, which is electrically-actuated automatically either by movement of the gear shift lever, as in the Selectroshift system, or by a governor sensitive to road speed and throttle pedal position, as in the Autoselectric system. It has been necessary, of course, to introduce additional features into these electric control circuits to cater for all the different conditions that arise during operation of the vehicle.

Briefly, the intrinsic advantages of the magnetic particle clutch are as follows. Since it is electrically-operated, its control can be grouped in such a way that the installation is simple and compact. In addition, there are no mechanical linkages that might be subject to wear or become out of adjustment. The torque that the coupling will transmit can be regulated easily, because it is determined entirely by the current flow in the coil. An important characteristic of this type of coupling is that the dynamic and static coefficients of friction between the powder and the driven and driving members are identical. This means that engagement is effected smoothly and there is no tendency to judder; in this respect, the unit is entirely different from any normal form of conventional friction clutch.

For a given flux density, that is, for a given current in the coil, the friction coefficient is independent of temperature up to about 600 deg C. Therefore, the torque capacity of the coupling is unaltered by changes in temperature, unless these changes are sufficient to affect the resistance of the coil and thus the excitation current that passes.

Important features of this coupling are that when it is fully energized there is no slip and, therefore, no mechanical loss, and when the magnetic field has completely collapsed there is no appreciable drag. In these respects, the unit differs radically from hydrodynamic drives. The iron masses of the field pieces have considerable heat capacity, and, therefore, intermittent slipping can be tolerated to a much greater degree than with the conventional type of friction clutch; there is also a considerable surface area available for heat dissipation. It is possible to extend the maximum operating temperature of the coupling using special heat-resisting types of electrical insulation. The electrical power consumption of the unit varies with the application, but for private cars, it is normally in the region of 50 Watts.

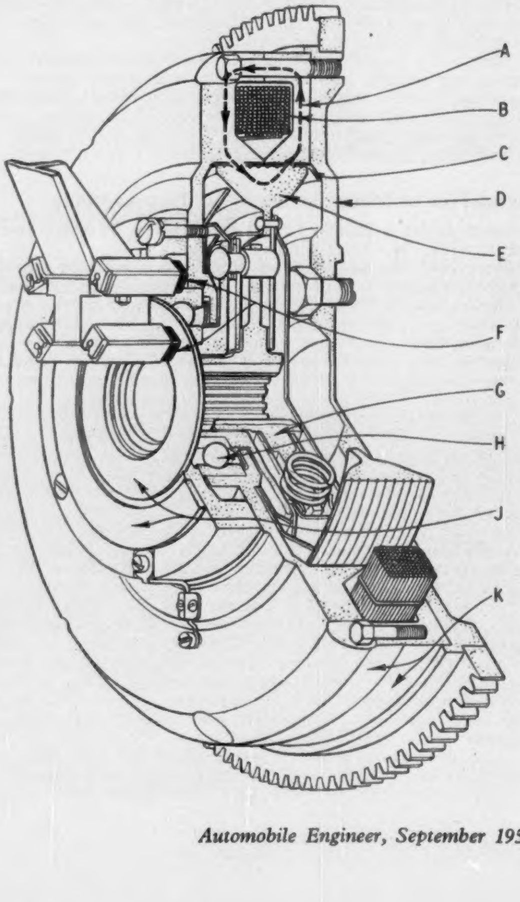
SELECTROSHIFT

Magnetic coupling unit

As has already been mentioned, the coupling unit now employed differs from that described in the May 1954 issue of *Automobile Engineer* in that its driven member incorporates a spring hub and is of different form; accordingly, the arrangement of the driving member also has been changed slightly. A sketch illustrating the general arrangement of a

Fig. 1. Diagrammatic illustration of a typical single magnetic coupling as used with the Smiths Selectroshift system

A the path of the magnetic flux; B excitation coil; C gap containing powder; D flywheel, input member; E output member; F brushes; G splined hub and torsional damper; H ball bearing that carries the output member; J slip rings; K field pieces



typical magnetic powder coupling unit, is shown in Fig. 1.

The driving member, which is spigoted and bolted to the rear face of a light flywheel, comprises two mild steel components that house the whole of the coupling assembly. One is a disc with a rim of heavy section, and the other is a ring clamped between the rim of this disc and the flywheel. An annular groove is machined in the front face of the rim and a second in the abutting rear face of the ring in order that, when the two components are assembled together, these grooves mate to form the housing for the excitation coil. The rim and ring together form the field piece. A housing for the single-row ball bearing carries the pick-up tracks for the carbon brush contacts and is bolted to the rear face of the driving member.

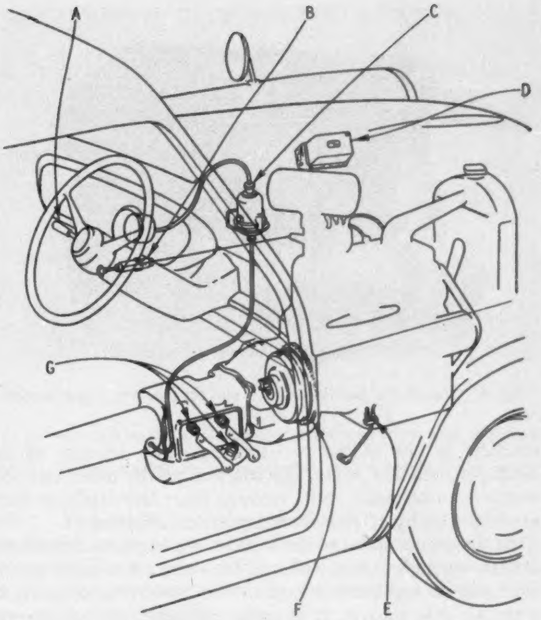
Housed in the cavity between the flywheel and the rear component of the driving member is the driven member. It comprises a conventional sprung centre component, with a steel ring of fairly thick section riveted to its periphery. The periphery of this ring is of plain, cylindrical section, with annular grooves machined round it. There is an 0·025 in gap between the ring and the field piece, or driving member. This gap is normally filled with the magnetic powder. When the coil is energized, the magnetic flux flows in the iron circuit enclosing the coil, and passes across the powder gap between the driving and output members. This causes magnetic particles to be attracted between the pole faces in such a manner that torque is transmitted from the driving member to the output member.

Obviously, the torque capacity of the unit increases with the quantity of powder employed, until the point is reached where no more magnetic particles can be accommodated in and around the gap. Up to a certain limiting value, at which the flux path is saturated, the torsional load that can be transmitted without slip varies linearly with the current in the coil. This saturation point, of course, varies with the quantity of magnetic powder in the unit.

The hub of the driven member, which is splined on to the primary shaft of the gearbox, is carried in the single-row ball bearing previously mentioned. When the coupling is rotating, the magnetic powder is flung outwards to the periphery of the housing, from which it cannot escape. On the other hand, when it is stationary, the powder is prevented from escaping past the splines in the hub, by a dished plate riveted to the front face of the sprung centre of the driven member. Flanged pressed steel rings, riveted alternately to the rear face of the driven member and the adjacent face of the driving member, form a labyrinth seal to prevent the magnetic powder from entering the ball bearing. A shielded ball bearing is employed, and its housing is shaped in such a manner that there is no tendency for lubricant to escape into the central chamber and contaminate the powder. This housing is vented so that any grease or vapour leaking into it from the bearing is immediately exhausted to atmosphere.

Control system

A simple control system, the layout of which is illustrated in Fig. 2, is employed. The circuit diagram for this system is shown in Fig. 3 and the control box in Fig. 4. Apart from the coupling itself, there are only eight components, and three of these are identical switches. The components are the gear lever switch, choke switch, governor, control box, throttle switch and the three neutral and high gear switches. In general, the system can be applied to any conventional layshaft type gearbox, but it is desirable that the synchro units in the gearbox are of good design. With this type of coupling, the inertia of the output member is relatively high and therefore the synchro units are more heavily loaded than with a conventional pedal-operated friction clutch. The main requirement is that the contacting surfaces of the cones are of adequate area and diameter.



A the manual gear-shift lever; B choke switch; C governor; D control box; E throttle switch; F coupling unit; G neutral and high gear switches

Fig. 2. General arrangement of the components of the Smiths Selectro-shift, semi-automatic transmission control system for cars

Components of the electric control system

Governor and G relay. The governor, Fig. 5, is driven in tandem with the speedometer. It actuates a pair of contacts which are made, to energize the G relay, at all speeds below approximately 10 m.p.h. When this relay is energized, the contact G_1 connects the clutch circuit to the dynamo, while the contact G_2 inserts the series resistances R_1 and R_5 into the dynamo field circuit and at the same time slightly boosts the feed to the dynamo field coils by connecting them through the resistance R_2 to the battery. When the car speed rises above 10 m.p.h. and the governor contact breaks, G_1 changes over to make the circuit from the battery, through the ignition switch, to the coupling. At the same time, G_2 changes over to cut out the dynamo field circuit modification so that battery charging is then effected in the normal manner. It follows that tow-starting can be effected at speeds above 10 m.p.h., when the contact G_1 makes the circuit between the battery and the coupling.

Mercury switches and top gear switch. To limit the value of the retardation torque that the clutch can transmit, and thus to smooth out light and closed-throttle downward gear shifts, a mercury switch arrangement, sensitive to fore and aft accelerations, is incorporated. This device is installed in the control box and incorporates contacts, which are broken when the car is not accelerating. Since a single switch would be affected by centrifugal acceleration experienced during cornering, two are employed. They are placed with their axes at 20 deg to each other, as viewed in plan. In other words, they are set with their axes inclined 10 deg each side of a line parallel to the longitudinal axis of the vehicle.

Normally, the circuit is from the battery, through the ignition switch and the resistance R_3 across the contact G_1, to the coupling. The resistance R_3, is, however, cut out under two conditions. Firstly, if the car is accelerating, the mercury switch contacts are made, and since they are connected in parallel with the resistance R_3, they short circuit it. If the car happens to be cornering at the same time as accelerating, centrifugal force is liable to break the

Fig. 4. The control box is compact, and easy to install and service

contacts in one of the two switches, but, because of the 20 deg installation angle, the contacts in the other one will continue to be made, so R_3 remains short circuited and there is no possibility of slip occurring at the coupling.

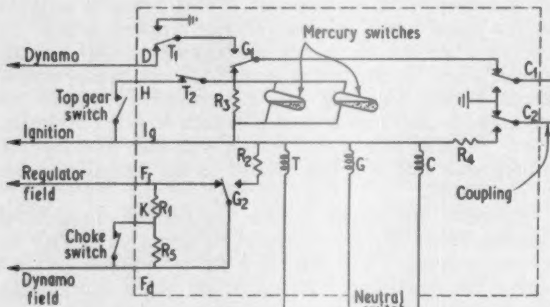
At maximum speed of the vehicle, the engine is developing a high torque output, while at the same time there are no fore and aft acceleration forces. To enable the coupling to transmit this torque, it is again necessary to cut out the resistance R_3. This is effected by the incorporation of a switch with contacts that are made when top gear is selected, Fig. 6. The circuit through this switch is in parallel with the resistance R_3, which is, therefore, shorted out when the contacts are made.

A second contact, T_2, actuated by the throttle switch relay, is incorporated in this top gear switch circuit. When the throttle is closed, the contact T_2 is broken so that the current once again has to flow through the resistance R_3. The reason for the incorporation of the contact T_2 in this circuit is to limit the current energizing the coupling to the value necessary to cope with the over-run torque, and thus to effect an economy in current consumption under closed throttle operating conditions.

Throttle switch and T relay. The contacts in the throttle switch, Fig. 7, which controls the T relay, are made when the throttle is closed. In the T relay is a change-over contact T_1, which is electrically connected to the G_1 contact. When the throttle switch contacts are made, the circuit from the dynamo to the coupling is completed through the contacts T_1 and G_1; and, when they are broken, the clutch coil is earthed through the contacts G_1 and T_1.

Energization of the T relay at speeds below 10 m.p.h. breaks the circuit from the dynamo to the coupling and earths

Fig. 3. Circuit diagram of the Selectroshift transmission control



the coupling coil. This causes the clutch to be released relatively slowly, and thus prevents the transmission from unwinding too rapidly. Energization of the T relay at speeds above 10 m.p.h. causes the T_2 contacts to be reopened and reduces the current consumption by the clutch, as has already been mentioned in the section dealing with the mercury switches and the top gear switch.

Gear shift switch, C relay and neutral switch. The gear shift switch is installed in the root-end of the gear shift control lever, Fig. 8. Its contacts are made when a force is applied to move the lever. The making of these contacts energizes the C relay which, in turn, changes over the contacts C_1 and C_2. This reverses the polarity of the coupling coil and a small reverse current is fed through the resistance R_4 to nullify the small degree of remanent magnetism in the iron, so that the coupling is immediately and completely disengaged.

A simple switch, actuated by a cam on the gear control lever on the gearbox forms the neutral switch, Fig. 6. The contacts of this switch are made when the control is in the neutral position, and so complete the circuit through the ignition switch, the C relay and the governor switch. Below 10 m.p.h. when the governor contacts are made, if the gear control is in neutral, the setting of the contacts C_1 and C_2 is such that the coupling is free.

Choke switch. With some types of carburettor, it is necessary to cater for the increased idling speed of the engine when the choke is in operation. To meet this requirement, a switch operated by the choke control, Fig. 9, is introduced. When the choke is in operation, the contacts of this switch

Fig. 5. Right: The governor unit which is driven in tandem with the speedometer

Fig. 6. Left: This type of unit is used for both the neutral and the high gear switches

are broken, but when it is not in operation, the contacts are made and the circuit through the resistance R_5 is bypassed. The breaking of the choke switch contacts places the resistances R_5 and R_1 in series, which modifies the dynamo field circuit to reduce the output.

Operation

The control system operates in the following manner. When the vehicle is at rest and the engine is idling without the choke in operation, the governor switch contacts are closed, so that the contact G_1 connects the coupling circuit to the dynamo, while contact G_2 inserts resistance R_1 into the dynamo field circuit and, at the same time, the dynamo field coils are connected to a supplementary feed from the battery through the resistance R_2. If the choke is applied, the resistance R_5 is introduced into the circuit.

To move off, the driver selects first gear and opens the throttle in the normal manner. As the engine speed is increased, the output from the dynamo builds up until the coupling is fully engaged; the take-up, being automatic,

is effected smoothly. As the speed of the car increases, the governor contacts break. This causes the G relay to change over the G_1 contact, which disconnects the dynamo and connects the battery through the ignition switch to the coupling circuit. At the same time, G_2 changes over to cut out the dynamo field circuit modification. Movement of the gear shift lever to select second speed makes the contacts in the root of the lever. This energizes the C relay and changes over the contacts C_1 and C_2 to reverse the polarity of the coupling coil and to bring the circuit through the resistance R_4 into operation to nullify the magnetic remanence effects and ensure that the magnetic coupling is completely disengaged.

After the gear shift has been completed and the control lever released, the contacts in the gear shift switch are broken. This de-energizes the C relay, which changes over the switches C_1 and C_2 to energize the coupling coil to transmit the drive in the newly selected gear. Subsequent upward changes are effected in a similar manner.

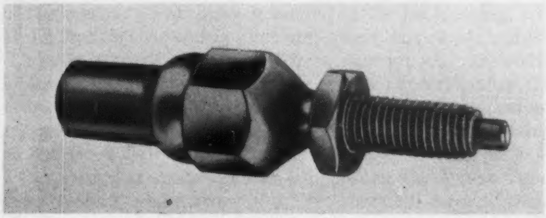


Fig. 7. This is the throttle switch, which controls the T relay

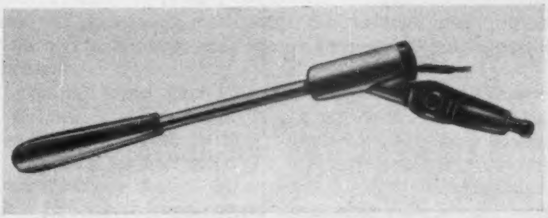
When the car ceases to accelerate, the mercury switch contacts are broken and the clutch is served through the resistance R_3. This not only economizes in current consumption, but also, by restricting the torque transmission capacity of the coupling, prevents fierce engagement of the coupling if downward changes are made with the throttle closed or only slightly open. As has already been mentioned, the top gear switch by-passes the resistance R_3, to cater for the transmission of adequate torque to maintain the vehicle at top speed. Downward changes are effected by operation of the gear shift switch in the same manner as for upward changes.

To ensure that even a novice driver can effect both upward and downward gear shifts without imposing undue strain on the transmission, irrespective of clumsy operation of the accelerator pedal during the shift, many features have been incorporated during the development of this control system. As a result, the design can now be said to be such that refined performance is obtained in all circumstances during both acceleration from rest and gear shifting. However, simpler control systems have been produced and have been applied satisfactorily, in particular to the smaller cars in which reduction in initial cost is a prime consideration. An example of such a simplified circuit is shown diagrammatically in Fig. 10. In this particular application, only two relays are employed in conjunction with the governor and gear shift switch.

AUTOSELECTRIC

General arrangement

The Autoselectric transmission comprises a double-coupling unit of the magnetic powder type, a simple three-speed, layshaft-type gearbox and the electric control arrangements. A noteworthy feature of the system is that throughout all gear shifts, tractive effort at the wheels is uninterrupted. This not only facilitates design to obtain jerk-free gear shifts, but also ensures that the transmission line from the gearbox through the final drive unit is not subject to shock loads. In addition, the danger of skidding due to sudden changes of torque on wet or greasy road surfaces is minimized. The magnetic particle coupling has been fully proved both in the semi-automatic and, more recently, in the fully automatic transmissions.



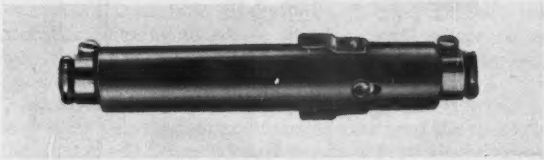


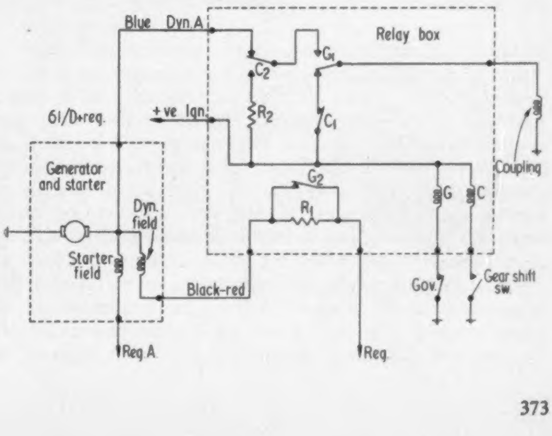
Fig. 8. Above: A switch is incorporated in the base of the gear shift lever

Fig. 9. Below: Another switch is actuated by the engine choke control

Although the gearbox is virtually unaltered by comparison with that described in the May 1954 issue of *Automobile Engineer*, design changes have been incorporated in the coupling and electric control circuits. In the clutch, the two driven members have been reduced in diameter, to just less than 7 in, to restrict their peripheral velocities. Both the coils are now housed in a stationary field-piece assembly spigoted and bolted in the bellhousing, instead of being attached to the flywheel. This has been done to reduce the moment of inertia of the flywheel and coupling assembly and thus enable gear shifts to take place more rapidly. In any case, a heavy flywheel is not required with this type of transmission, since there is no danger of the driver's stalling the engine as a result of fierce engagement of the coupling—the single coupling unit employed in the Selectroshift transmission is not so heavy as this double unit, and therefore it is not generally necessary to use the stationary coil layout for the semi-automatic system. Another change that has been made is the incorporation in each driven component, of a sprung centre similar to that employed in the Selectroshift system.

From the illustration of the coupling and gearbox, Fig. 11, it can be seen that the double coupling unit comprises four main components. One is the stationary field-piece, which

Fig. 10. An example of a simplified control circuit, in which only two relays are employed, together with the governor and a gear shift switch, and which can therefore be manufactured at a relatively low cost



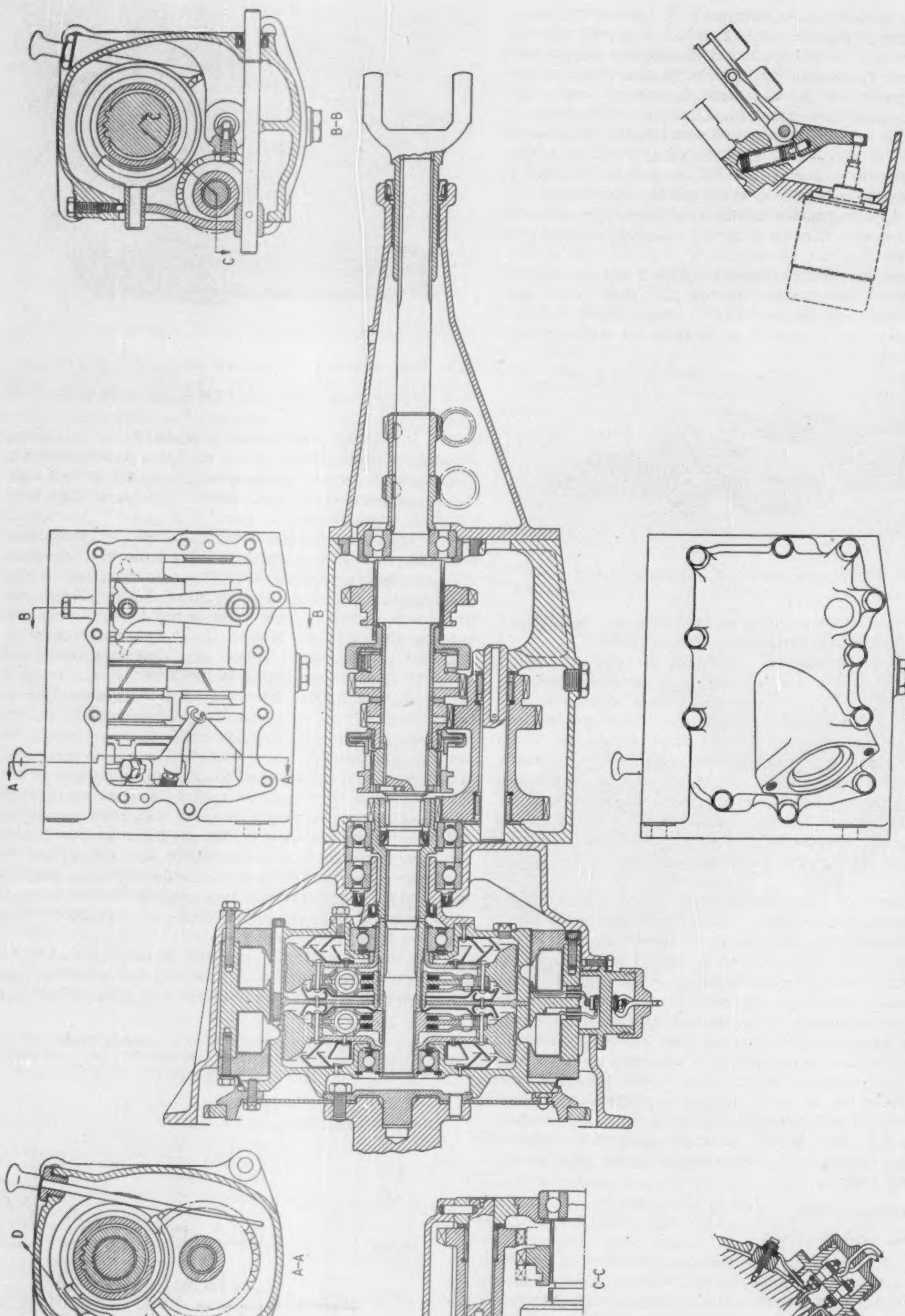


Fig. 11. ARRANGEMENT OF THE THREE-SPEED GEARBOX AND DOUBLE, MAGNETIC COUPLING OF THE AUTOSELECTRIC TRANSMISSION

The scrap view in the bottom left-hand corner is a part-section, showing the trimming resistors of the magnetic coupling

houses the two energizing coils and is spigoted and bolted to the bellhousing, as already described. The second is a rotating intermediate field-piece secured to and, in fact, forming part of the engine flywheel. This component forms a housing for the two driven members, its cylindrical wall being interposed between the peripheries of the driven members and the stationary field-piece. It is driven through the medium of a spring-steel plate spigoted to the rear flange of the crankshaft. This plate is clamped between the crankshaft flange and a retainer plate that has a central boss spigoted into a counterbore in the rear end of the crankshaft. The retainer plate, which is bolted and dowelled to the crankshaft flange, also radially locates the rotating part of the coupling assembly, since a spigot on the front end of this assembly fits round it. The spring plate drive automatically allows for the slight axial movements of the crankshaft relative to the coupling assembly.

Support for the rotating intermediate field-piece is afforded at the rear by a ball bearing carried in the bellhousing, and at the front by the spring plate and spigot, already described. There is a small air gap, 0·020 in, between the stationary and rotating intermediate field-pieces. To guard against the entry of chips from the starter gear teeth, or other foreign matter, into this gap, a flanged pressed steel ring is bolted to the front face of the stationary field-piece and projects into an annular space between a lip round the flywheel and the periphery of the flange of the rotating field-piece. There are two large peripheral grooves round the rotating field-piece to ensure that the magnetic flux will pass through the driven components.

The third and fourth main components of the coupling assembly are the two driven members. That at the front is the direct drive member, while that at the rear is the indirect drive member. Each is carried in a ball bearing housed in the intermediate field-piece. The small annular gap between the periphery of each driven member and the rotating field-piece is filled with magnetic powder. Pressed steel rings, forming labyrinth seals, are employed to prevent the powder from reaching the sealed ball bearings at the centre of the unit. When the coils are energized, the flux passes from the stationary field-piece, across the air gap into the rotating field-piece, and thence through the magnetic particles into the driven members.

From the illustration, it can be seen that the driven component of the direct drive, or front, coupling is splined to a forward extension of the mainshaft. This extension is passed through the primary shaft, which is in the form of a sleeve with the primary gear machined on the rear end of it. The front end of this sleeve is splined to receive the driven component of the indirect, or rear, coupling.

Thus, when the front coupling is engaged, the drive is transmitted directly by the mainshaft, right through the gearbox to the propeller shaft. When the rear coupling is engaged, the drive is transmitted through the primary gear to the layshaft, on which are the first and second speed pinions. These pinions are in constant mesh with the first and second speed gears respectively, which are free to rotate on the mainshaft.

Integral with the first speed gear is the centre component of a roller type free wheel. The outer component is a drum-shaped member with a central boss also free to rotate on the mainshaft. Dog teeth are machined round the periphery of this central boss and when forward drive is selected, an internally-toothed, sliding component of a dog-clutch connects it to the mainshaft.

This first speed dog-clutch is actuated by a manual selector, which has two positions: forward and reverse. The reverse gear teeth are machined on the periphery of the sliding component. When reverse is selected, the dog-clutch sleeve is slid rearwards: in this position, the teeth on the dog-clutch mesh with the reverse idler pinion, which is in constant mesh with the first speed pinion on the layshaft.

Second speed gear is engaged by a solenoid-operated selector. This selector actuates a dog-clutch to connect the second speed gear to the mainshaft, which then rotates faster than the first speed gear and therefore brings the free wheel into operation. Since the first speed gear dog-clutch still remains in engagement, the change back from second to first gear is effected simply by de-energizing the solenoid and at the same time momentarily de-energizing the rear magnetic coupling to relieve the dog-clutch of torque, so that it can disengage. The first speed free wheel then locks again, to take up the drive.

A simple baulk ring, instead of a synchro unit, is employed to prevent the engagement of second gear until the speeds of the driving and driven components have been synchronized. For first to second gearshifts, the direct drive coupling is momentarily engaged to reduce the engine speed and thus effect synchronization. Movement of the solenoid core to engage the second speed gear actuates a switch to release the direct drive coupling again.

The change from second to top gear is effected by releasing the rear coupling, engaging the front coupling, and at the same time de-energizing the solenoid to permit the second speed dog-clutch to disengage. For the change down again from top to second speed, this process is reversed; since the throttle is already open, the engine speed automatically increases to effect synchronization.

Control system

This system is illustrated diagrammatically in Fig. 12. A four-position control lever, mounted on the steering column, actuates a switch incorporating eight sets of contacts, engaged in pairs. The four positions are as follows: "hold second," in which one pair of contacts completes the circuits to the control and couplings, while a second pair makes the blip solenoid circuit; "drive," in which one pair of contacts completes the circuit to the control and couplings, while a second pair makes the circuit between the top gear relay and the top gear contact in the governor; "neutral," in which one pair of contacts breaks the circuits to the controls and couplings, while the other pair completes the circuit to the electric starter motor—this provides starter protection; and "reverse," in which one pair of contacts completes the circuit to the controls and couplings, while the other pair of contacts is used to close a circuit to the indirect coupling when the emergency plug is in use. The selection of reverse, by the control lever, mechanically engages reverse gear.

An emergency plug is supplied. In the event of failure in the control circuit, this plug can be used to isolate the automatic control, and then the gears can be operated manually. When the plug is in use, first speed gear is obtained in the "hold second" position and top gear in the "drive" position. Neutral and reverse are still obtained manually in the normal manner.

A governor sensitive to road speed, and also incorporating contacts mechanically actuated by the throttle pedal, determines when the gear shifts take place. This governor incorporates a permanent magnet eddy-current coupling to form the speed-sensitive element, which actuates a three-position switch. In two positions the contacts are made, and in the third they are open. The electric signals from this governor actuate relays to control the couplings. Because of the built-in hysteresis of this governor, the speed at which down-shifts occur are lower than those at which up-shifts occur, for a given throttle position. This characteristic is essential to ensure that the gears are not continually shifted up and down if the car is held at a constant speed at the point at which a gear change is normally required.

An over-riding switch, termed "hold second," is also incorporated, so that the driver can prevent the transmission from changing up from second to top speed. This switch is for use when engine braking is required, or when the driver wishes to prolong his acceleration in second gear. However, should the road speed exceed a certain value, the "hold second" switch is over-ridden by the engine protection switch in the governor, and top gear is automatically re-engaged.

There are three throttle-actuated switches. One is made and energizes the V relay when the throttle is closed. This relay then opens contact V_1 to prevent current from flowing from the dynamo to the coupling coils, when the vehicle is stationary, and thus obviates the possibility that the vehicle might creep forward.

Of the other two throttle-actuated switches, the part-throttle switch 1 is set to close after the throttle is opened 9 deg, and it also energizes the V relay. Therefore, below the 9 deg throttle opening point the V_2 contact is open and the R_3 resistance is introduced into the circuit of the direct drive coupling, to smooth out light-throttle gear changes and to give a measure of current economy. The part-throttle switch 2 is set to open after 20 deg of throttle opening to prevent the relay F from actuating the F_1 contact and bringing the resistance R_7 into the indirect speed coupling circuit. This resistance prevents jerk during top to second gear changes whenever the throttle opening is smaller than 20 deg.

Another switch, actuated by the choke control, is incorporated to introduce resistance R_5 into the dynamo field circuit when the choke is in use. This prevents a jerky take-off from rest when the engine idling speed is high.

The dog switch shown on the circuit diagram signals to the synchronizing relay E, when synchronism has been effected and second gear engaged. This switch is actuated by the gear shift solenoid, which also actuates the solenoid switch. The latter switch has three functions: first, when it is open, it de-energizes the main coil in the gear shift solenoid; secondly, after "hold second" has been selected, it switches off the blip solenoid when synchronism is effected; and finally, it completes the circuit for the energization of the T relay until this relay has performed its function, which is described in detail later, towards the end of the section headed "Operation."

The solenoid incorporates two coils and it actuates the solenoid switch, which is timed to open a fraction of a second after the dog switch closes. One of the two coils carries a high current and is energized for only the short period necessary to effect the gear change, and the other carries a low current to hold the second gear in engagement as long as it is required.

The only other switch is the engine protection switch. It is closed by centrifugal action at vehicle speeds over 50 m.p.h. In the event of the driver's selecting "hold second," this switch prevents the change down into second gear until the road speed has dropped below 50 m.p.h.

There are four rectifiers in the control circuits. The first is Re_1, which, when bottom gear is selected, prevents feed-back energization of the E relay from earth through contact X_1, rectifier Re_2, contact X_2, the V relay, the column switch and the ignition switch. The rectifier Re_2 prevents energization of the E relay through the throttle switch.

Two functions are performed by the rectifier Re_3. First, it prevents the de-energization of the synchronizing relay E if the ignition is switched off then on again when the car is operating in top gear. In these circumstances, the E relay energization is maintained through Re_3 and the top gear contact in the governor. Secondly, Re_3 prevents energization of the B relay through the dog switch and the rectifier Re_4 when second speed gear is in engagement.

The fourth rectifier, Re_4, prevents energization of the E relay at the beginning of the bottom to second gear change. It blocks the circuit through the solenoid switch contact E_1 and rectifiers Re_3 and Re_1.

Of the remaining components that comprise the electric control system, the functions of the contacts, relays and blip solenoid are described in the section headed "Operation." This leaves only the R_4 resistance to be dealt with here. Because the two coupling coils are embedded in a common field-piece, the magnetic field of one coupling may spread into the other. This is only serious when the indirect coupling is energized and tends to cause the direct coupling to drag. To prevent this, the resistance R_4 is connected in parallel with contact B_1, to energize slightly the direct drive coupling, even when the contact B_1 selects the indirect coupling. Since the coils of the couplings are wound in opposite senses, the field thus produced in the direct coupling counteracts the leakage from the indirect coupling. Drag on the indirect coupling when direct drive is engaged does not matter, since the indirect gears are floating on the main-shaft; in fact, it is probably advantageous since it ensures that the lubricant film is continuously maintained in the gear bearings.

Operation

The car can be started only when the control lever is in the neutral position, since the starter circuit is broken if the lever is moved to select any of the gears. To move away from rest, after the engine has been started and is idling, the control lever is moved into the "drive" positions. Under these conditions, the governor contacts are signalling for bottom gear by energizing the bottom gear relays X and G. At the same time, the V relay is energized through the closed throttle switch.

The contacts associated with these relays operate as follows:

(1) X_1 is connected to earth to prevent the energization of the second and top gear relays.

(2) X_2 selects the throttle switch to complete the circuit through the V relay.

(3) G_1 selects the dynamo as the source of power for the coupling.

(4) G_2 modifies the dynamo characteristic by introducing R_1 into the circuit from the regulator field to the dynamo field and R_2 into the circuit between the ignition switch and the dynamo field, through the control lever switch and choke switch. When the choke is in use, the choke switch contacts are opened, and R_5 is also introduced into this latter circuit.

(5) V_1 is opened and the circuit to the indirect coupling is broken.

When the throttle pedal is depressed, the throttle switch is opened, and the V relay is de-energized. This causes the contact V_1 to close and the rising current from the dynamo to be fed through the contact B_1 to the indirect coupling. The drive is then taken up and the car moves away in bottom gear.

When the road speed rises out of the first gear range for the particular throttle setting, the governor switch moves from the low contact to the open circuit position, thus signalling for second gear. This de-energizes the X relay. As a result, contact X_1 cuts out the G relay and cuts in the B relay through the solenoid switch and the contact E_1, which is already closed; at the same time, it cuts in the second gear relay, C, through the contact E_2, which also is already closed. The contact X_2 selects the part-throttle switch 1 to energize the V relay when the throttle opening exceeds 9 deg.

The de-energization of the G relay causes the contact G_1 to select the circuit through the ignition switch as the source of supply for the couplings. At the same time, the contact

G_2 changes over to remove the modification of the dynamo field.

Energization of the top gear relay B selects the direct coupling through the contact B_1 to reduce the engine speed during the upward change to second gear. Incidentally, contact B_2 also changes over, but this has no effect, since the contact C_2 is broken.

Energization of the C relay in fact sets the C_2 contact to make the indirect coupling circuit through R_6. In this condition, the energization of the indirect coupling is sufficient to prevent engine run-away during the short period required for the build-up of the field of the direct coupling. At the same time, the C_1 contacts are closed to make the circuit through the main winding and hold winding of the solenoid to earth. This solenoid is thus energized and tends to engage the second gear dog clutch; however, until synchronization is effected, engagement is prevented by the baulking mechanism.

Energization of the V relay closes the contact V_2 and cuts out the resistance R_3, to give full energization of the direct coupling to transmit maximum torque for deceleration of the engine. It also closes contact V_1, but this has no effect, since the circuit from the dynamo is open at G_1.

When synchronization occurs, the gear solenoid is able to move over to engage the gear. This first of all closes the dog switch, which energizes the synchronizing relay, E. Contact E_1 de-energizes the B relay, and E_2 holds the E relay in, independently of the dog switch. As a result of the de-energization of the B relay, B_1 changes over to energize the indirect coupling and B_2 replaces the E_2 contact to hold in the C relay, so that the circuit to the solenoid is retained. The mechanical arrangement of the solenoid switch is such that it is opened just after the dog switch closes. On opening, the solenoid switch de-energizes the main coil of the solenoid, leaving only the holding coil in the circuit, to economize in current. In this condition, the car is operating in second gear and the bottom gear is free wheeling.

When the road speed relative to the throttle setting rises into the top gear range, the governor switch changes over to make the top gear contact and energizes the B, or top gear, relay through rectifier Re_4. This causes contact B_1 to divert the current from the battery to the direct coupling while contact B_2 de-energizes the C relay and, together with contact C_2, slugs the indirect coupling. The slugging action involves connecting the coupling coil to earth through C_2 and B_2, instead of leaving it on open circuit. This enables the current induced in the coil, by the collapse of the magnetic field, to flow freely and thus delay for a short period the complete de-energization of the coupling. As a result, power continues to be transmitted through the indirect coupling until the direct coupling field has built up to take over. Contact C_1 has already been opened by the de-energization of the C relay, so that when the direct coupling takes over, and the pressure on the second gear dog clutch is released, the second gear disengages to complete the change into top gear.

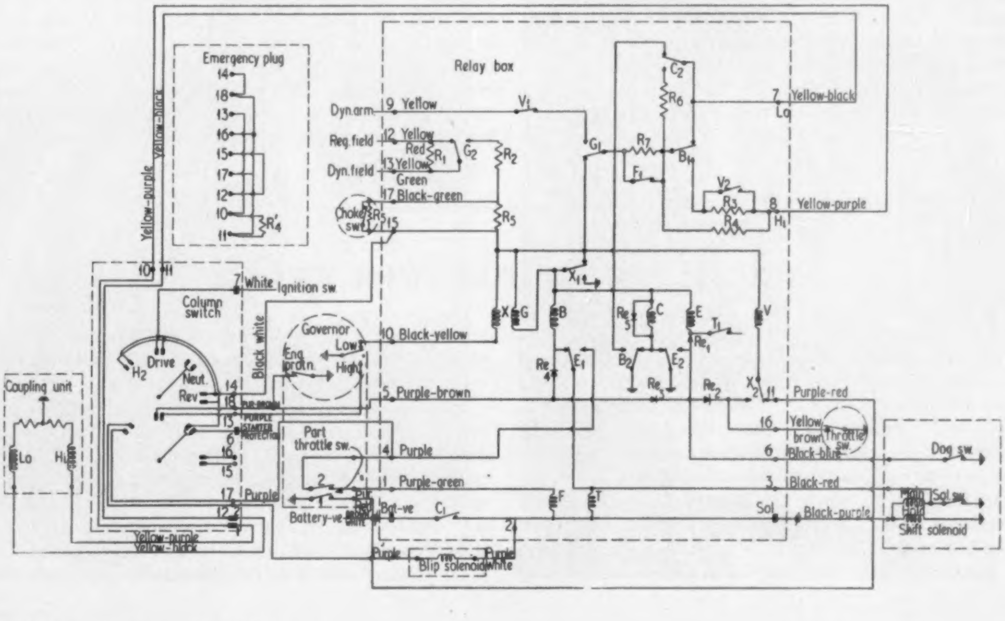
The change down again occurs when the road speed drops from the top to the second gear range for the particular throttle setting. In this condition, the governor contact opens to signal for second gear. This de-energizes the B relay, and contact B_1 selects the circuit of the indirect coupling, while B_2 energizes the C relay. Contact C_1 then closes, energizing the solenoid and at the same time preparing the circuit for the F relay. This latter circuit passes through part-throttle switch 2, contact E_1 and the solenoid switch to earth. Therefore, if the part-throttle switch 2 is less than 20 deg open, the F relay will open the contact F_1 so that, until the solenoid switch opens, R_7 reduces the excitation

Fig. 12. DIAGRAM OF THE ELECTRICAL CIRCUIT FOR THE THREE-SPEED AUTOMATIC TRANSMISSION

All the connections between the units are made with 14/0·012, except the main solenoid connections, marked ϕ, which are in 65/0·012. In the event of failure of the clutch control system, the emergency plug can be fitted in place of the nine-pin plug on the steering column switch. This enables manual control to be obtained, giving first gear in the "hold second" position and top gear in the "drive" position; then, neutral and reverse are still obtained manually, in the normal manner, by moving the control lever mounted on the steering column

Energization of the relays causes the following movements of the contacts housed in the electric control unit:

B relay—B_1 selects the direct clutch and B_2 connects the indirect clutch through C_2 to earth
C relay—C_1 is made and C_2 connects with R_6
E relay—E_1 changes to de-energize the B relay, and E_2 breaks the C relay circuit and holds the E relay in, regardless of the dog switch position
F relay—opens F_1, bringing R_7 into the clutch circuit
G relay—moves the G_1 contact so that the dynamo serves the clutch circuit, and changes the G_2 contact to modify the dynamo field circuit
T relay—closes T_1 to energize the E relay
V relay—closes V_2 to cut out R_3 and opens V_1



of the indirect clutch. This ensures that the change down from top to second gear is effected smoothly. On the other hand, if the throttle is open more than 20 deg, so that the part-throttle switch 2 is open, the circuit to the F relay is broken and it follows that there is no possibility of engine run-away when down changes are made while the engine is delivering a high torque. The collapse of the field in the direct coupling takes the load off the engine, which, therefore, speeds up until synchronization occurs and the second gear dogs are engaged by the solenoid, to give second gear.

If the speed falls still further, and the governor switch completes the first speed circuit, calling for another downward gear shift, the following changes occur in the electric control system. The X relay is energized, earthing the contact X_1 and thus energizing the G relay. Energization of the G relay changes over the contact G_1 to select the dynamo as the source of power for the coupling and also changes over the G_2 contact to modify the dynamo field circuit. The X_1 contact also cuts out the top and second gear relays B and C, and the synchronizing relay E. De-energization of the C relay opens the contact C_1 and de-energizes the shift solenoid. Contact X_2 completes the circuit through the dog switch to the V relay to open the contact V_1, and de-energize both couplings. This releases the load on the second speed dog clutch, which can then disengage. The disengagement of the dog clutch opens the dog switch and, provided the throttle and the throttle switch are not in the fully closed position, de-energizes the V relay and closes the contacts V_1 to supply the indirect coupling again through B_1. If the throttle is closed fully, the V relay remains energized through the throttle switch.

Two special conditions have to be catered for. Should the driver wish to hold second gear when descending a steep hill, he moves the steering column control lever from the "drive" to the "hold second" position. This causes the governor to signal for second gear, since it takes the governor top gear contact out of circuit. As a result, the B relay is de-energized and the C relay is energized. Contact C_1 closes and the solenoid tries to engage second gear. At the same time, the blip solenoid is energized through the contacts on the column control lever switch, contact E_1, and the solenoid switch. The action of the blip solenoid is to open the throttle and increase the engine speed. When synchronization occurs, the second speed dog clutch engages and the second gear solenoid switch opens. This causes the blip solenoid and main coil of the second gear solenoid to be de-energized. The car then remains in second speed, unless the road speed drops into the bottom gear range or rises above 50 m.p.h.

The gear does not remain in the "hold second" position above 50 m.p.h., because of the action of the engine protection switch. This switch is incorporated in the governor and operates centrifugally. As the road speed of 50 m.p.h. is passed, it closes to give a permanent top gear signal from the governor to prevent a change down. The "hold second" condition can be preselected at the higher speed and will come into operation as soon as the road speed drops and the engine protection switch therefore opens automatically.

Another special condition arises when the car moves off downhill from rest with the control lever in the "hold second" position and with the throttle only slightly open. If gravity, instead of the engine, accelerates the car into the second speed gear range, the engine speed is too low for synchronization. This condition is opposite to that obtained normally when a signal to change up from first to second gear is given by the governor. Accordingly, the action of the direct coupling in pulling down the engine speed would be particularly inappropriate. The main coil of the second speed solenoid would be trying to engage the second gear dog clutch at too low an engine speed, and the continued action of the direct coupling would prevent the engine speed from rising. Eventually, the second speed solenoid would burn out.

At first sight, the remedy would appear to be to open the throttle wide, to increase the engine speed. However, this would only transmit the drive through the direct coupling and therefore increase the road speed, thus making even higher the engine speed that would be necessary for synchronization.

This false top gear condition is brought to an end by the action of the thermal relay T. The T relay is in circuit whenever contact C_1 and the solenoid switch are closed; that is, when the governor or the control lever is calling for second gear, and the second gear dog clutch is not engaged. After 30 sec, the T relay energizes, closing contact T_1. This energizes the E relay, so that contact E_1 opens and de-energizes the B relay to bring the false top speed condition to an end. Contact B_2 moves back to hold in the C relay, while contact E_1 also completes the second gear blip solenoid. As a result, the throttle is opened and the engine speed is automatically increased until the second gear dog clutch engages to bring into operation the normal "hold second" condition.

Conclusion

This fully automatic scheme has been tested on a number of different makes of car and has completed many thousands of miles. These tests have shown it to be satisfactory. The transmission is neither costly, nor does it lead to power losses, as do most hydrodynamic drives. Therefore, the fuel consumption of the engine is at least not impaired and may even be improved by the use of this automatic transmission, and there is no need to employ an abnormally high-powered engine to ensure satisfactory operation.

BLACKHAWK PORTO-POWER WEDGIE

THE Blackhawk Porto-Power attachment, called the Wedgie, comprises a pair of alligator type jaws, actuated by a built-in hydraulic ram. Its jaws are of high quality, malleable cast iron, and they are pivoted on a large diameter, hardened and ground steel pin. Equipped with the Blackhawk Spee-D-Coupler, the Wedgie can be fitted to any of the pump units produced by this manufacturer.

The applications for which the Wedgie can be employed in the workshop include pushing gears and bearings off shafts—it is even small enough to be used, in some instances, inside gearboxes and rear axle housings—manoeuvring heavy components into position and pushing out dents in panelling; in fact, it is designed for use in situations where leverage has to be applied in confined spaces.

It is 6¼ in long by 2 in wide. At the thickest end, the overall dimension of the unit is 1¾ in and it tapers to ⅜ in thick at the tips of the jaws, where a thrust of 15 cwt can be exerted. The Wedgie is connected to the hydraulic pump unit by a 6 ft long, armoured flexible hose. In this country, the distributors of the equipment are E. P. Barrus (Concessionaires) Ltd., of 12 Brunel Road, Acton, London, W.3, from whom further information can be obtained.

BALL-JOINT FRONT SUSPENSION

An Economical Arrangement Widely Used on American Cars

BALL-JOINT front wheel suspension is, of course, by no means new. In fact, it has been used, on and off, for some fifty years past. Interest in this construction has been revived, however, through its intensive development by Thompson Products, of Cleveland, U.S.A. Ball joints of their design and manufacture are widely used on American cars, including Buick, Ford, Lincoln, Mercury and Oldsmobile, all of which have coil springs in the front suspension. Ball joints of Chrysler design are used throughout the Chrysler line of cars with torsion-bar springing.

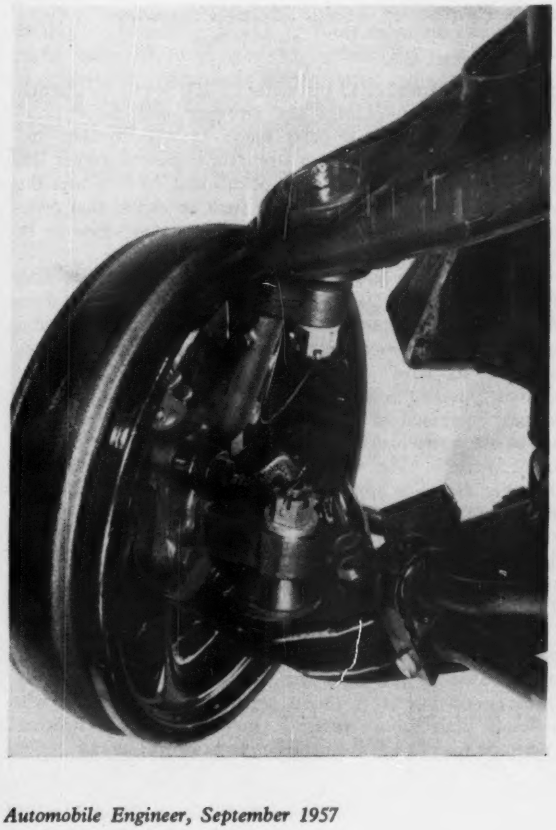
In the conventional independent front-wheel suspension, the vertical wheel-spindle bracket, which carries the king pin, is hinged to the upper and lower swinging arms by two horizontal pins; up-and-down movements and swivelling movements are thus permitted by two independent sets of bearings. In the ball-joint suspension, the king pin is omitted; the spindle bracket is carried by upper and lower ball joints, which permit both movements. Thus, fewer parts are used and accurate alignment of the swinging-arm bearings is no longer necessary.

In broad terms, the use of ball joints in a front suspension goes back to Lanchester's patent of 1900. His idea was to use ball-ended radius rods to work with quarter-elliptic springs to position the front axle. The first patent to cover the proposed use of ball joints for both steering and suspension was Heyermans' British patent of 1920. Other patents, by Porsche, Daimler-Benz and Sizaire followed, but the present-day arrangement, carrying the wheel load on the lower ball, in compression, seems to have first been outlined in Heynes' British patent of 1945.

When Thompson Products engineers took up the development of the ball-joint suspension system, some years ago, they soon decided that the steering torque inherent in existing designs was too high to meet American standards of steering ease. In order to improve matters, they added a roller thrust bearing in the lower socket, relieving the spherical bearings of the vertical wheel load. This change proved rather too effective, so a small clutch, consisting of a spring-loaded bronze washer, was added in the upper socket, to act as a wheel-wobble damper. Tests indicated that a spring load of about 300 lb provided satisfactory damping for rough roads, without introducing too high a resistance for easy parking. Later on, after various clutch materials had been tested, it was found that surfaces of steel working against steel were quite satisfactory.

Next, a ball thrust bearing was substituted for the roller thrust bearing. In some designs, separate ball races are used; in others, the stud and ball themselves are hardened and ground to form the ball races, an exceptionally cheap and compact arrangement and one that permits the stud to be

Front and rear views of the Chrysler ball-joint front suspension



formed from bar stock in a simple manner by cold heading.

The next design point to receive attention was the seal. In the first arrangement, the sockets were machined with flat surfaces on the opening side and were sealed by means of a fabric washer sandwiched between two sheet-metal discs, the whole being held in place by means of a light spring. This seal did not prove satisfactory, and, as long experience with seals for steering tie-rods had shown that rubber seals would not resist freezing and eventual failure by cracking, an entirely new design was developed. This consists of a spherical steel washer, which rubs on a spherical surface formed on the socket (on the upper joint, two concentric washers are used, to afford a larger angular range of movement). The washer, or washers, are held against the mating surface by means of a compressed Neoprene sponge, which is, in turn, secured by a sheet steel cup.

Next came the problem of lubrication. At first, grooves were machined in the socket, but it was later found possible to place the grooves on the ball only, a simpler machining operation. Three equally spaced spiral passages are provided; grease enters near the head of the ball stud, passes through the spiral grooves and is flushed out under the seal.

During development work, it was found that, given sufficient spring action, the grease lubrication was effective in preventing scoring of comparatively soft contact surfaces. On smooth roads, however, scoring took place and it was decided that both the ball and socket surfaces must be hardened.

Attempts at induction-hardening the socket did not prove satisfactory, because of the non-uniform section of this part. Furthermore, use of a steel suitable for both forging and induction-hardening increased the material cost. It was, therefore, decided to use a hardened sheet steel liner, nitrided all over. The final design of grease grooves, with both ball and liner hardened to 60 Rockwell C, has proved very satisfactory from the point of view of wear.

It is, of course, out of the question to manufacture balls and sockets that will obtain a bearing over their entire contact area. Even if they were selectively assembled, the scrap would be prohibitive. The recess in the socket is therefore flattened slightly to bring the contact area in a zone about one-third of the way down from the small opening. In later designs, the distortion was transferred to the ball, making it very slightly of a toroidal or doughnut, shape, and leaving the socket spherical.

During the development of the Thompson Products ball joint, over 400,000 miles of road testing was carried out. The success of the ball-joint front suspension would indicate not only what can be accomplished by the intensive development of one small group of parts, but is also a reminder that it is unsafe to assume that one particular construction, although used for many years, is not necessarily the best.

Ball-joint front suspension offers a number of advantages over the conventional design. It affords light weight, greater durability, much easier servicing and repair, a slight increase in frame width and thus more engine space (or, alternatively, increased front wheel lock) and simplicity in that braking loads can be carried directly to the wheel spindle bracket (or, alternatively, the brake backing plate may become a part of the bracket) all at no increase in cost.

Mass-Produced Plastics

Latest Developments Hold Hope of Components Competitive with Metal Pressings

If plastics vehicle parts could be produced at prices comparable with those existing for pressed steel and aluminium fabrications, operators would reap considerable benefits. Their light weight, greater durability, ease of repair, corrosion and impact resistance and possibility of being self-coloured are qualities in themselves that confer real advantages compared with metal components.

Research into the production side of reinforced plastics seems to indicate that it is possible for plastics materials to be economic even with production runs of 1,000 components per week. Furthermore, the use of press tools, which such quantity production would involve, opens up possibilities of using materials that would show an improvement in strength and heat resistance.

Materials other than glass fibre, such as flax, paper, asbestos, and metal mesh are being considered as alternative or supplementary resin-reinforcing media. Asbestos particularly is an attractive alternative, since it is as strong as glass fibre, but has more consistent mechanical qualities, and is at least equally fire-resistant. It is also cheaper, which is a big factor. Glass fibre is now the most expensive constituent of reinforced plastics.

For currently used, hand wet-lay-up methods, to which operators are economically restricted for small-scale production, polyester resin is the most satisfactory plastics material, because it will set at room temperature. But if press methods are employed, cheaper phenolic resin can be used and curing times can be reduced very considerably. Normally, handling phenolic resin is not easy, because it requires temperatures in the order of 120 deg C for curing. Such phenolic mouldings are stronger and more heat-resistant than polyester parts made by the "bucket and brush" method. For a given strength, therefore, rather less material is required. The effect of this may be to reduce the cost of mass-produced plastics to such an extent that own-make wet lay-up mouldings by operators may cease to be an economic proposition.

Different resins have been investigated by Bakelite Ltd. to determine their relative heat-resistance when in the form of glass cloth mouldings. Phenolic, polyester, silicone, melamine and epoxide resins were compared by giving each laminate six days' exposure at 250 deg C. These tests showed phenolic resin to give the best performance; it actually increased in strength as time proceeded. Polyester was weakest and lost strength rapidly towards the end of the exposure time. The silicone laminate was the next best to the phenolic. For applications where temperature does not exceed 250 deg C, phenolic laminates are strongest. However, where strength is not of major importance, for instance, for unstressed mudguards and bonnets polyester is good enough. In the unlikely event of temperatures above 250 deg C being met, silicone laminates are required.

Polyester and epoxide resins can be given greater heat-resistance by embodying asbestos dispersions; they can be moulded under low pressures. This opens up new possibilities, and operators might consider experimenting with asbestos fibre reinforcement. One firm, Turner Brothers Asbestos Co. Ltd., of Rochdale, Lancashire, already offers

a selection of asbestos reinforcements for plastics production. Principal among them is a felt called Durestos, which, when impregnated with polyester resin has been found to compare very favourably with glass fibre mat moulding.

One of the new production methods consists of putting a lump of plastics dough between two dies, which squeeze it out into a panel of the required shape. The glass or asbestos reinforcement can either be embodied as a dispersion in the dough or the mat of reinforcement can be put in the die first and the lump of pure resin placed in the middle before pressing. This idea involves fairly high pressures and since matched dies are required, tool cost is likely to approach that for pressed steel parts. Although the same accuracy of the dies would not be required, their surface finish must be of a very high order.

For matched die moulding, the composition of a suitable dough would be 28 parts filler, 42 parts polyester resin and 30 parts glass fibre, according to Ashdowns Ltd. A die temperature of 125 deg C is commonly used to accelerate curing during moulding. Generally, the curing time per $\frac{1}{10}$ in thickness is two or three minutes by this technique. Faster production can be obtained by removing the moulding in a part-cured state and completing curing in an oven. Material cost might be offset by using coloured resins, and so eliminate the need for painting. In the event of the glass weave showing through, a skin of p.v.c. sheet could be moulded to the outer surface.

Where quantity justifies, the glass reinforcement can be supplied to the press shop, preformed to the shape required, this saves much handling and trimming. Resin can then be applied by brush or spray or simply wrapped in a thin paper bag and placed in the middle of the reinforcement before the dies close. Any press method can use part-cured resin-impregnated glass fibre sheet in the same way as a sheet of steel would be handled. The spray idea has its application to hand lay-up too: it is cleaner than the brush method and does not take so long.

Injection moulding, which is analogous to die casting, is being employed by the Bristol Aeroplane Co. Ltd. for its reinforced plastics production. With the mould open, glass fibres are distributed over the surface or a preformed mat is dropped in. The mould is then closed and hot air is passed through it to dry the fibre. Finally, resin is injected into the closed mould until it flows out, bubble-free, from judiciously placed risers or exhausts.

Still being used in an effort to reduce plastics production costs is the older idea of employing a rubber bag to press a plastics moulding into shape with only a single die. This method has been found to be particularly useful for moulding sandwich components of great stiffness. A plastics sandwich may consist of a plastics foam core, on either side of which is bonded a thin, reinforced plastics sheet. The resultant part has greater strength-to-weight ratio than many other forms of construction. In America, the bodies of large tandem-axle, insulated van trailers have been made from sandwich plastics panelling. This method of construction reduces framing to a minimum, because the walls have sufficient stiffness to be completely self-supporting.

A similar method, using aluminium honeycomb sandwich construction, is applied in aircraft production to combine maximum rigidity with lightness. The principle is that the further apart the two skins can be separated, the greater is the resistance of the sandwich to bending. Sandwich construction has been started in this country by Plaxtons, who have applied it without expensive moulding techniques.

Quality is the key of success of plastics mouldings, and this is why inspection is so important. If the design can incorporate a small portion otherwise wasted, this can be cut off and tested. Sonic methods are being developed for detecting flaws in mouldings and for determining the degree of cure, without resorting to destruction. Any improvement in the constancy of plastics mouldings will be bound to spread confidence in them.

Former suggestions that the fatigue resistance of reinforced plastics might not be good have proved to be unfounded. Plastics are being used in the aircraft industry for the very reason that for unit weight they show improved fatigue-resistance in comparison with aluminium alloys. They are not so sensitive to flaws as are metals. Bristol Aircraft Ltd. gives the following criteria for fatigue and creep resistance of reinforced plastics: a laminate should withstand ten million cycles of a load not exceeding one fifth of its breaking strength unless it has crazed when the load is applied; it should be able continuously to hold a load, two-thirds of that needed to break it, for at least six weeks without extending. A slightly reduced load can be held for more than a year without deflection.

It is likely, therefore, that outstanding improvements will be made to the quality and versatility associated with plastics mouldings over the next few years. With mass-production now a realistic, economic possibility, reinforced plastics may be expected to be more and more widely applied.

CURRENT PATENTS

A REVIEW OF RECENT AUTOMOBILE SPECIFICATIONS

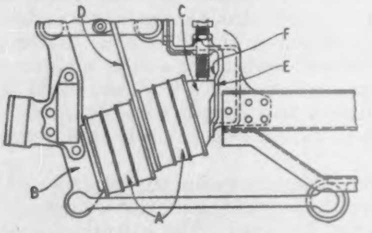
Adjustment of independent wheel suspension

This invention relates to a wedge-type adjustment for the rubber sandwiches of an independent front wheel suspension and constitutes an improvement on an earlier specification, No. 716563. The wedge has steep-angled surfaces for coarse adjustment and a shallow-angled surface for fine adjustment.

Two sandwich elements A, each comprising rubber blocks with non-resilient interleaves and end plates, are interposed between the wheel carrier B and an abutment wedge C engaging a chassis bracket. Between the adjacent end plates of the sandwich elements is an arm D pivotally connected to the upper suspension link in order to prevent the elements canting out of parallelism under load.

Wedge C is vertically adjustable so that the angular relationship of the upper and lower suspension links and the wheel carrier B for a given load can be altered by varying the height of the contiguous sandwich element. The inner face of the wedge and the complementary face of the chassis bracket are each formed with vertical surfaces E, providing fine adjustment, and steeply angled surfaces F for coarse adjustment.

On initial assembly the wedge is arranged at its uppermost position and the sandwich elements are fitted. The wedge is then



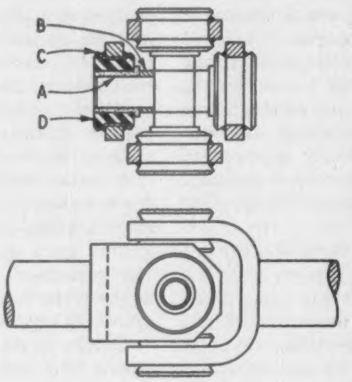
No. 762020

adjusted downwards and the steeply angled surfaces give a substantial horizontal component of movement and the loading of the sandwich is rapid. Thereafter, the vertical surfaces are engaged and fine adjustment is possible to obtain the correct chassis height. The arrangement also facilitates dismantling, as the sandwich elements can be completely freed with clearance to lift from shallow locating recesses or dowels. *Patent No.* 762020. *Metalastik Ltd.*

Nylon-bushed universal joint

In this Hooke-type universal joint the bearings for the pivot pins are each made of Nylon or other synthetic material that needs no lubricant when in sliding contact with metal. This bearing bush is split longitudinally throughout its length and is urged into contact with its associated pin by an encircling rubber bush which is preloaded in the eye of the yoke arm. As fitted initially the split in the bearing bush is of a width sufficient to afford an adequate measure of self adjustment for wear.

The example illustrated shows a nylon bush A with its locating flange abutting a spacing collar B on the cross-pin. A metal ferrule C is brazed in the eye of the



No. 762305

yoke arm to accommodate the rubber bush D.

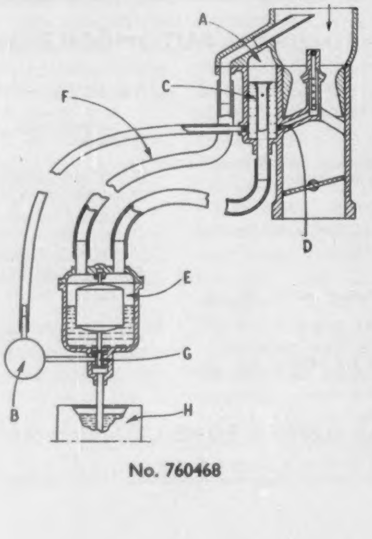
Specifically, the joint is intended for incorporation in a vehicle steering mechanism and it is claimed that the rubber bushes minimize the transmission of road shocks to the steering wheel. *Patent No.* 762305. *Morris Motors Ltd.*

Overflow-type carburettors

When a carburettor of this type is heated to an unduly high temperature, fuel may be passed towards the induction pipe of the engine, either as liquid or vapour, as a consequence of the boiling of the fuel. The object of the invention is to eliminate this disadvantage.

On the side of the carburettor body is a closed chamber A to which fuel is supplied by a pump B. In chamber A is a tube C, the upper edge of which determines the level of the fuel which passes to the carburettor nozzle by way of main jet D. Excess fuel delivered to chamber A overflows into tube C and is collected in a remotely sited chamber E which is connected by conduit F to the main air intake of the carburettor. Thus the pressures in chambers A and E are equal to that existing in the main intake.

In chamber E is a float controlling



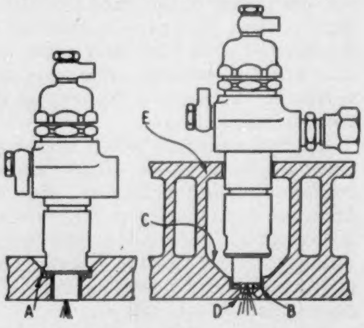
No. 760468

two-way valve G selectively connecting the pump intake to chamber E or to the fuel tank H according to the amount of fuel present in chamber E.

If vapours are evolved in large amounts from the fuel in chamber A, they are compelled to flow through tube C to chamber E and thence through conduit F to the main air intake. In the course of this travel condensation will occur and consequently the amount of vapours reaching the intake will be much less than if chamber A was in direct communication with the intake. The condensation effect will be the greater as the temperature of chamber E is the lower. Accordingly, chamber E is insulated from heat or is mounted in a position where it is cooled by fresh air flow. In suitable circumstances it is possible practically to avoid any flow of vapours to the intake. *Patent No.* 760468. *Solex (France).*

Injector mounting on air-cooled diesel engines

Improvement in the cooling of the fuel injection nozzles on an air-cooled, compression-ignition engine is the aim of this invention. In conventional practice the injector assembly is seated in the cylinder head with an interposed washer at the lower end of the cup nut attaching the



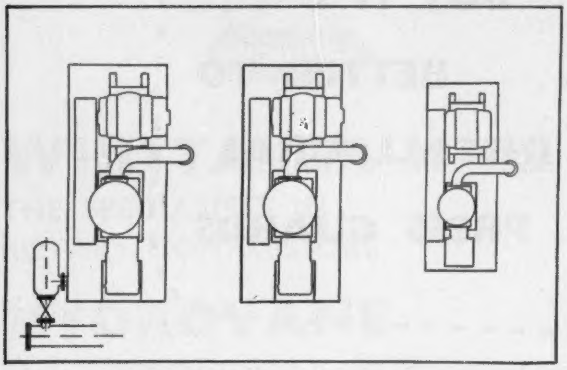
No. 762222

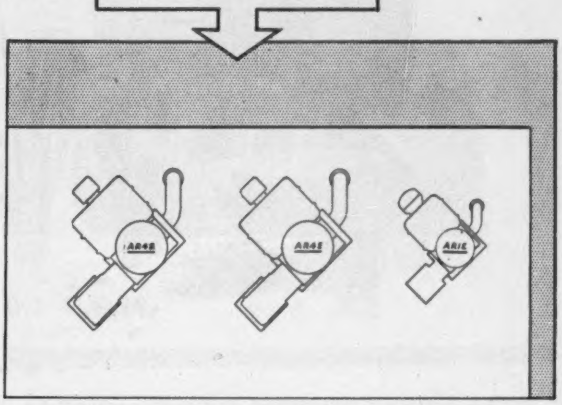
nozzle to the holder, as at A. The protruding end of the nozzle is closely enshrouded in the bore in the cylinder head casting and is thus isolated from the cooling air passing over the cylinder head and can be cooled only indirectly.

In the new arrangement the injector assembly is seated with an interposed washer at the lower end of the nozzle member, as at B. The seating is arranged in a shallow recess in the base of a frusto-conical depression C in the cylinder head casting so that the length of the reduced-diameter injection aperture D is as short as is practical. This aperture may be of frusto-conical shape at its end opening to the combustion space in order to ensure that the fuel spray is unobstructed.

On the cylinder head, the cooling fins are bridged by an integral web E which is bored in alignment with the nozzle seating to furnish a location and a steady for the nozzle holder when the injector is mounted. Cooling air flows over the cylinder head, the fins, and both sides of web E and baffles or ducting may be provided to ensure adequate cooling of the injection nozzle. *Patent No.* 762222. *Ricardo & Co. Engineers, Ltd.*

THIS SPACE FREE





The shaded area indicates the space you save by installing Atlas Copco AR-E 'Power-Pack' compressors in place of standard machines

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The Atlas Copco AR-E 'Power-Pack' range is a series of heavy-duty stationary compressors, specifically designed to cut down on floor space and installation costs. The diagrams above show how these compact machines save on space—up to 25% in this typical installation.

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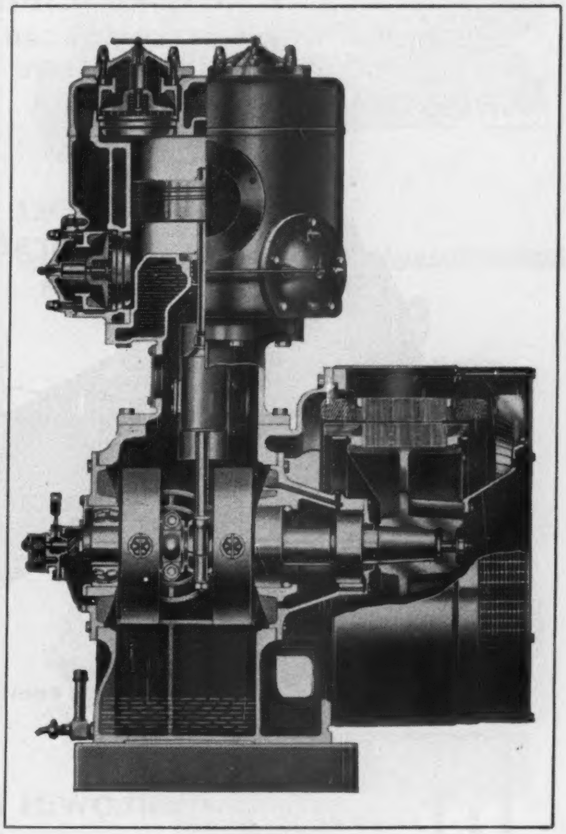

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C.18

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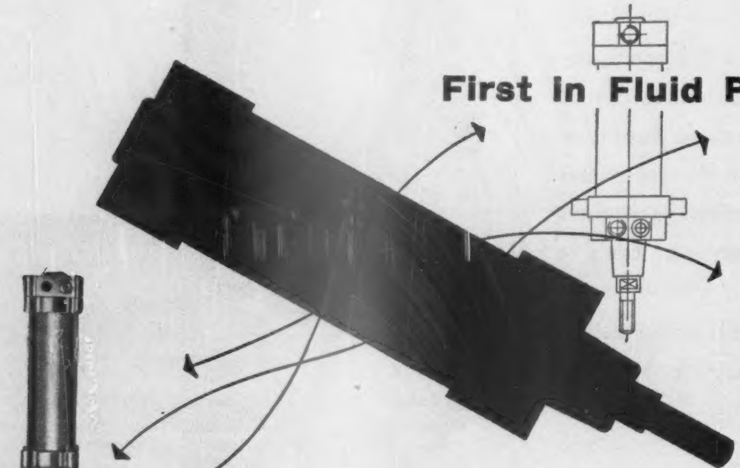

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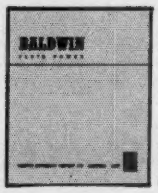

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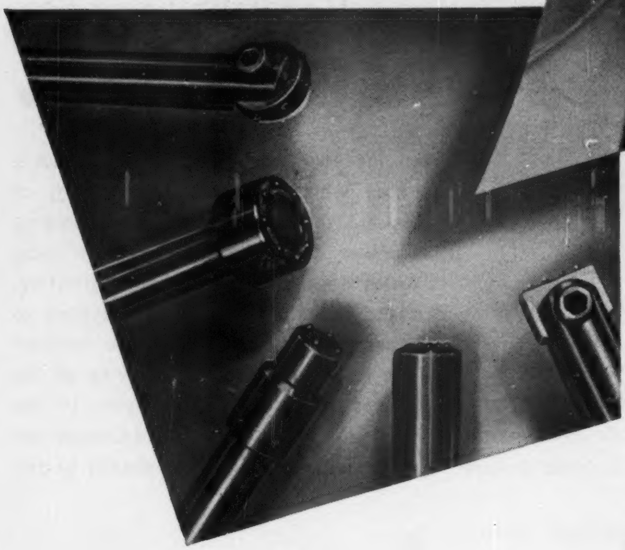

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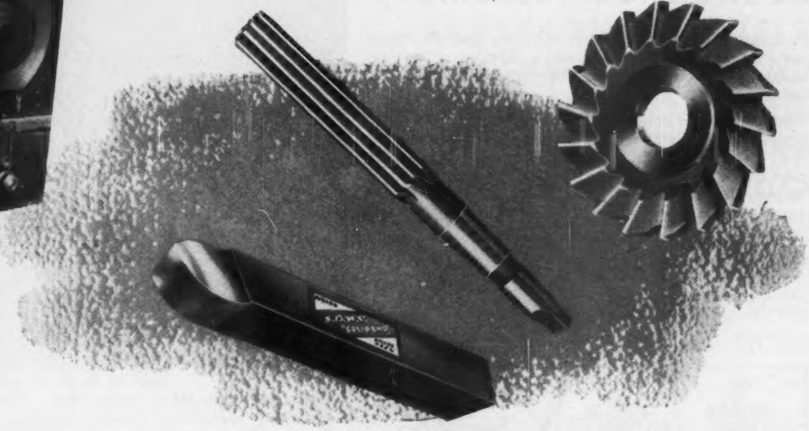

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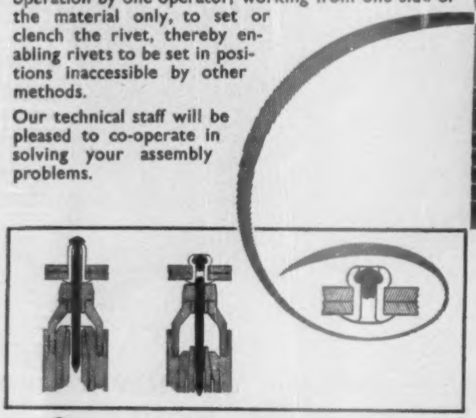
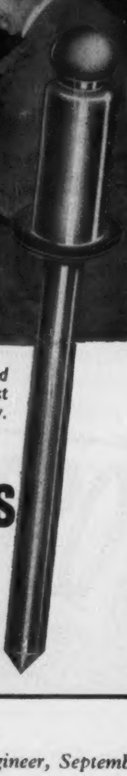


The illustration above shows "Pop" Rivets being used attaching springs for holding moulding finishers—just one of the many applications in the motor industry.



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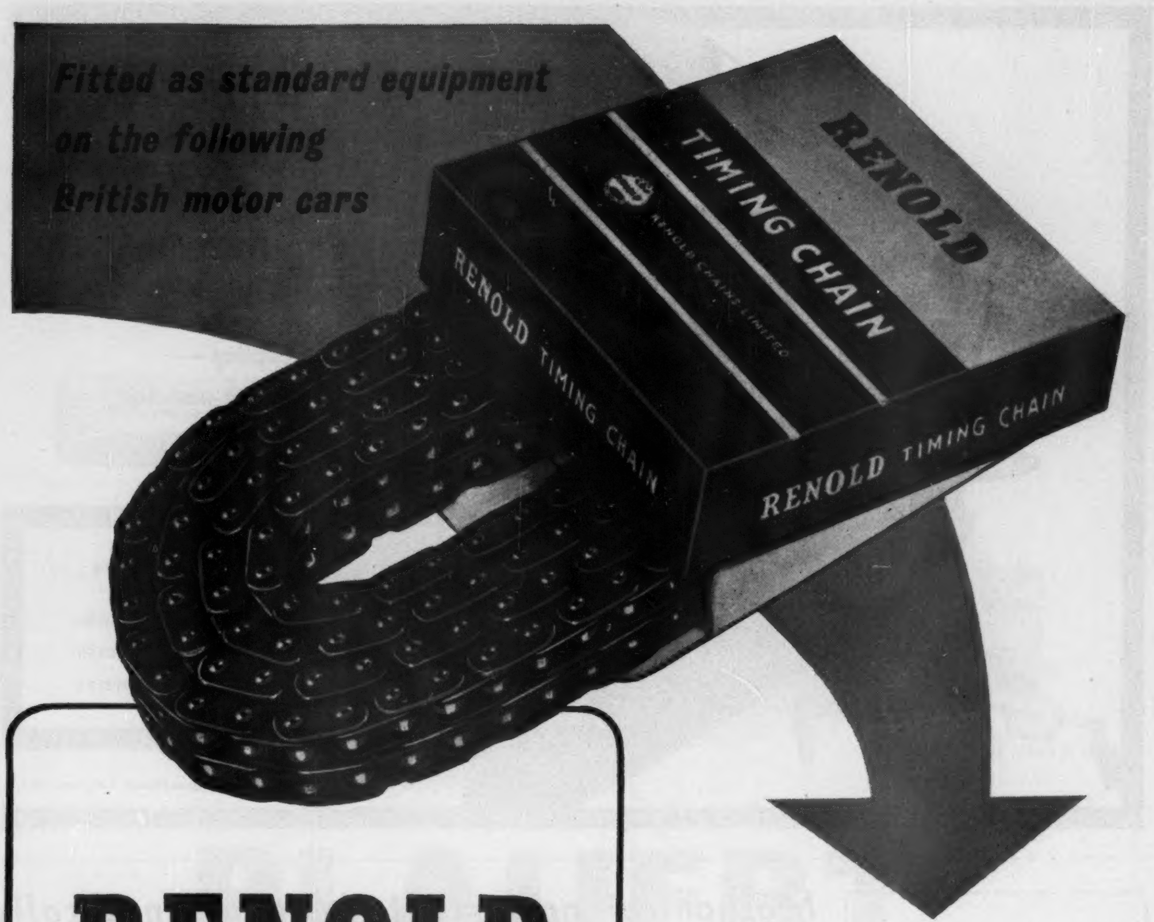

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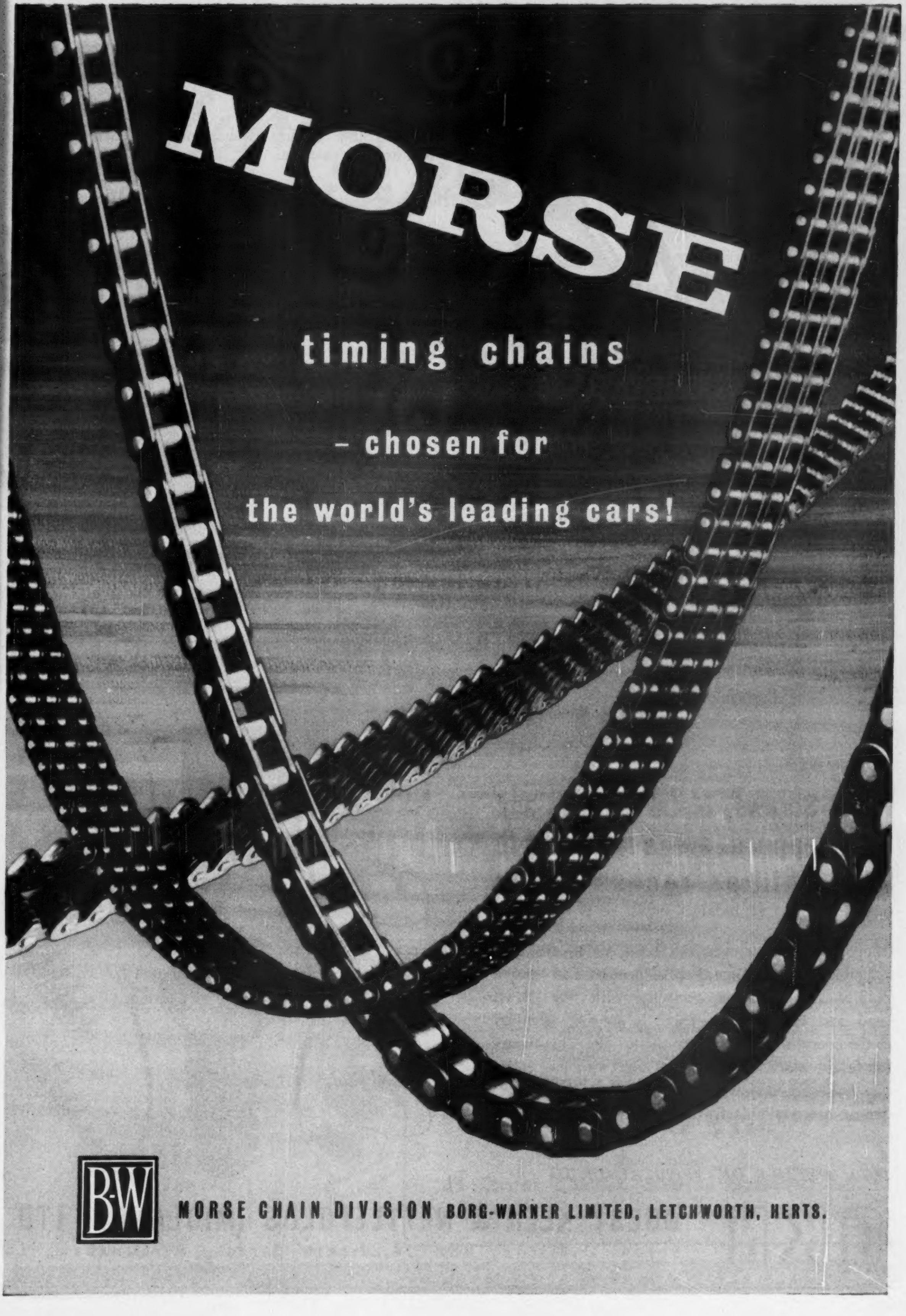

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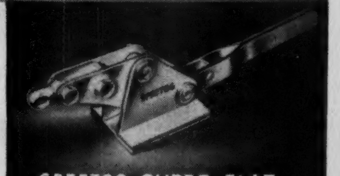

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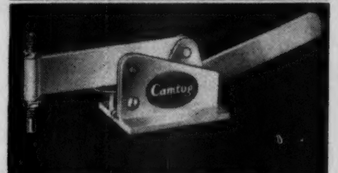

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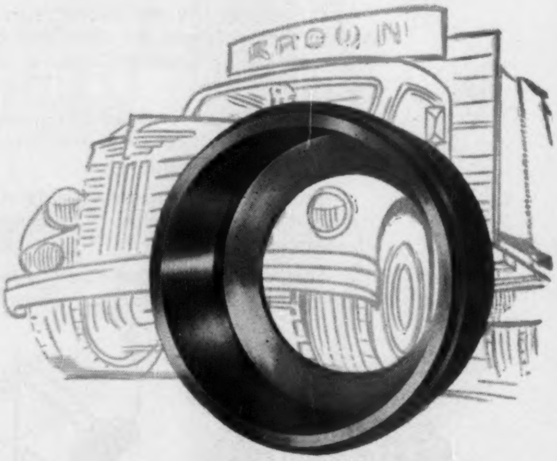

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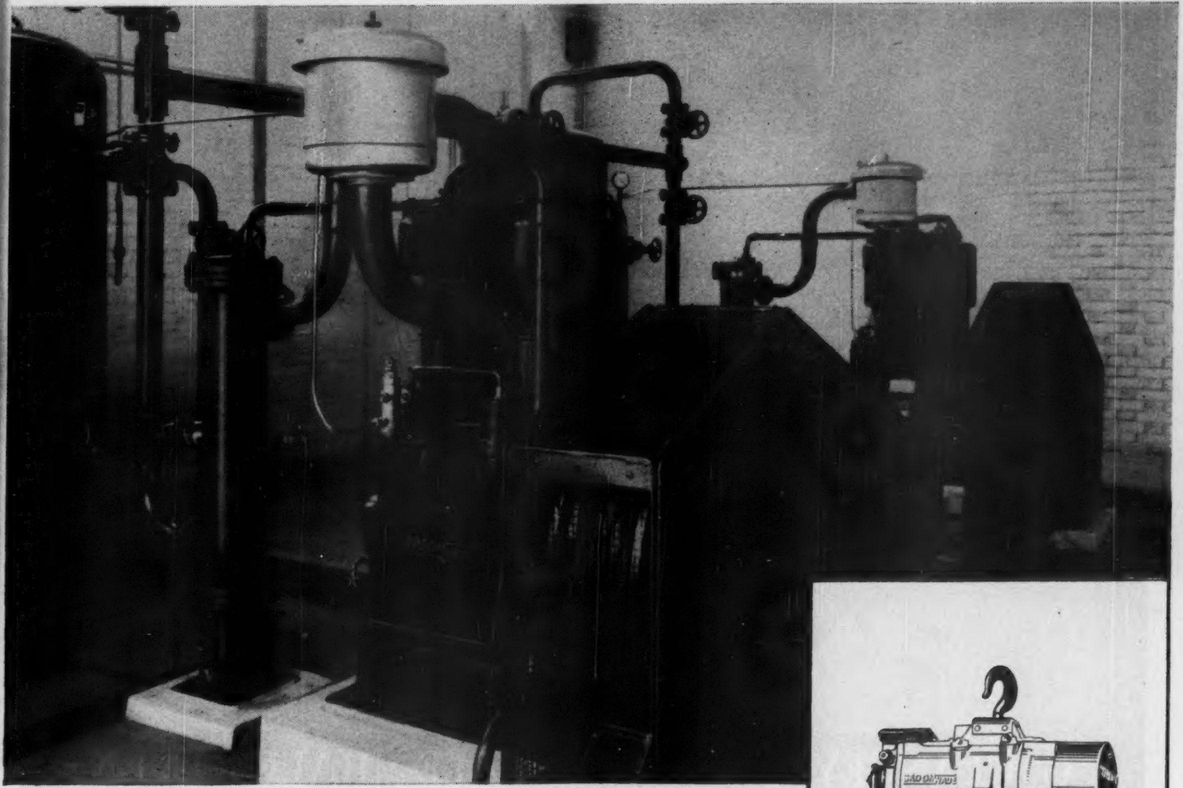

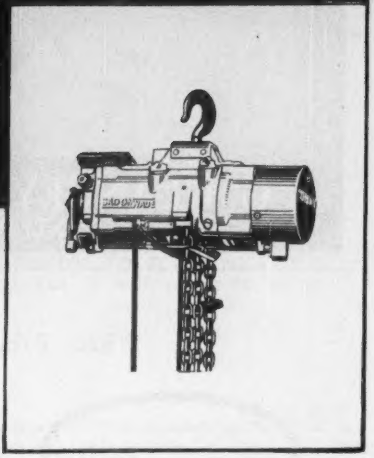

"Broomwade" Type D Compressor in use at Rover Car Works, Solihull. (Photograph by courtesy of The Rover Co. Ltd.)

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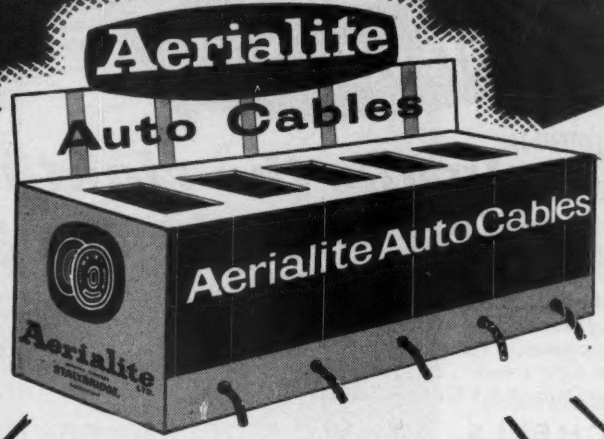

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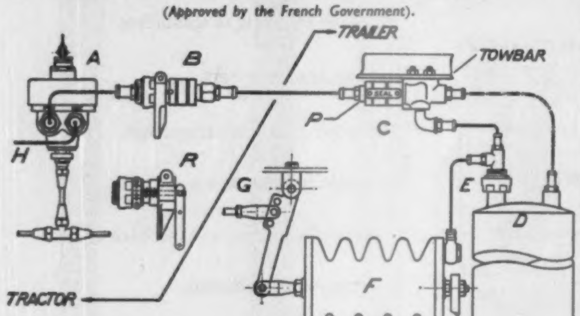

- **A.** Hydraulic Reaction Valve LV 207 Dual Control, shown fitted to Hydraulic Pipe Line on Tractor.
- **B.** "C" type Coupling with Auto. Shut-off Valve, attached to rear of Tractor.
- **C.** Breakaway Valve SBS. 256 (or SBS. 257) attached to Tow Bar of Trailer.
- **D.** Vacuum Tank on Trailer.
- **E.** Non-return Valve.
- **F.** Power Unit on Trailer operating linkage **G** to Trailer Brakes.
- **H.** Hose connecting LV 207 to source of Vacuum. Hose connections shown as solid lines are those used in normal operation of Brakes. The Hose shown in broken line connects the Vacuum Tank to the Power Unit when Valve "C" is operated in emergency
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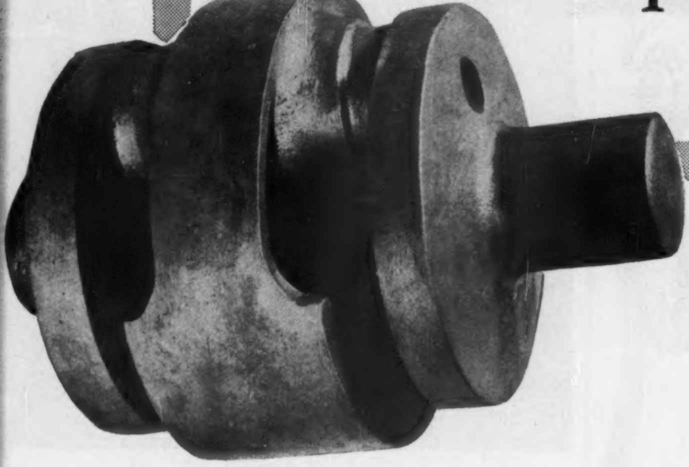

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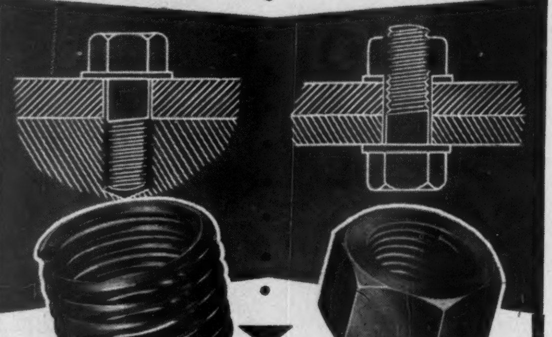

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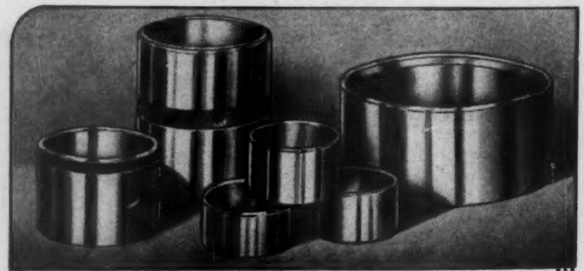

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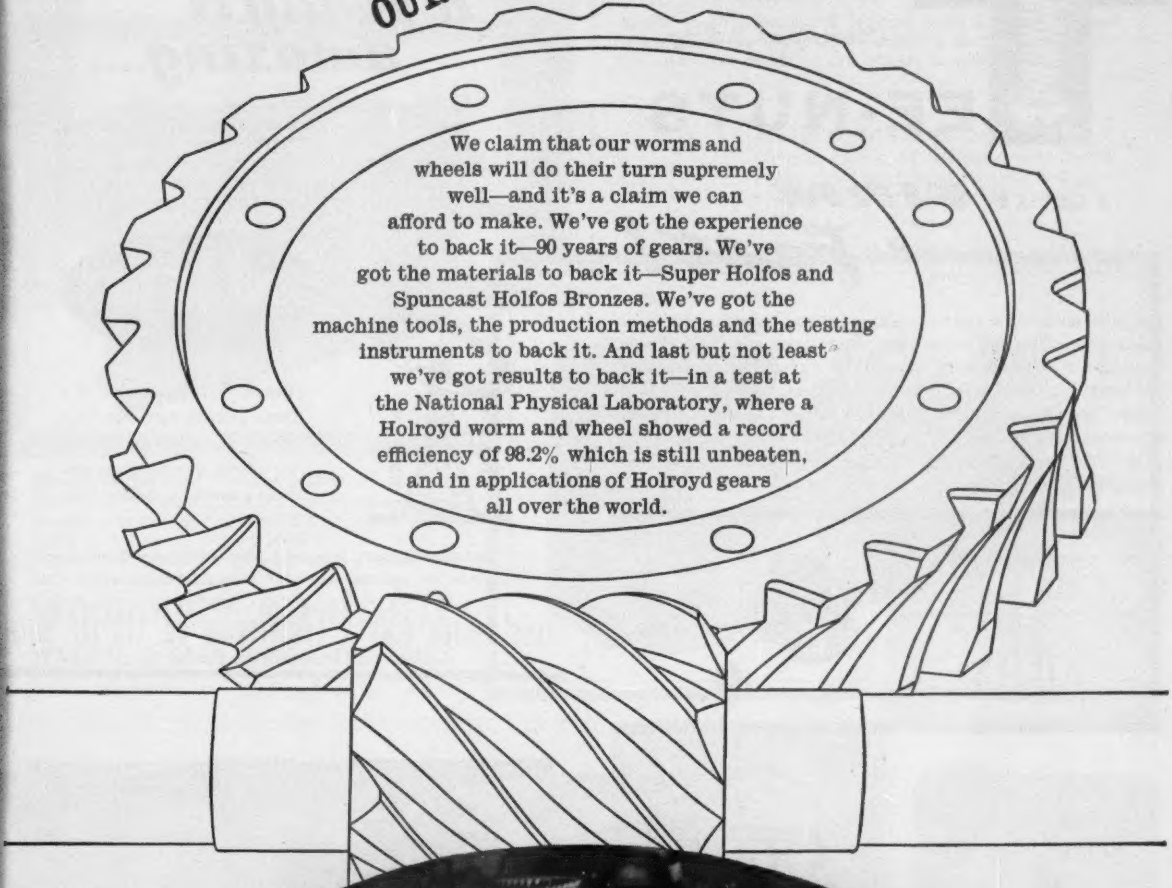

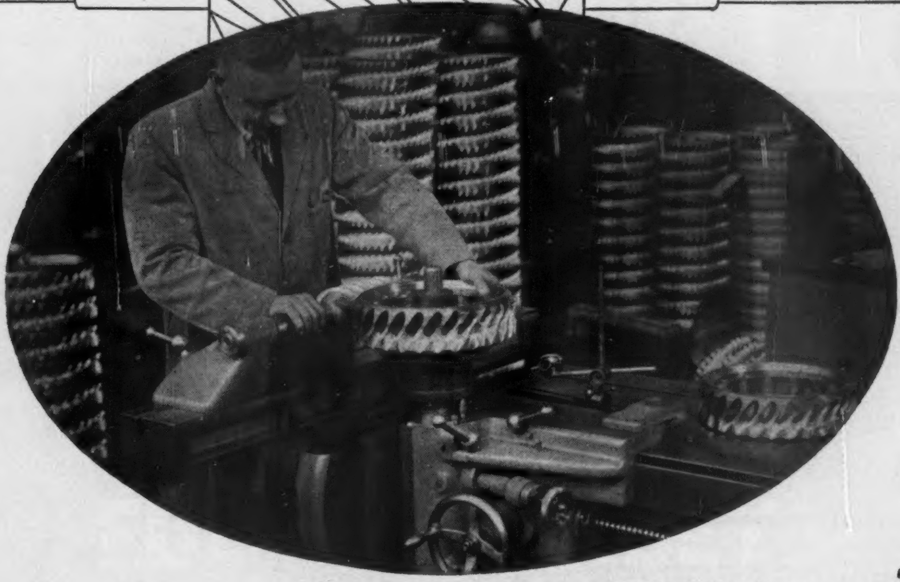

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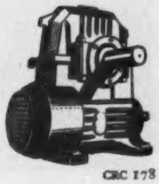

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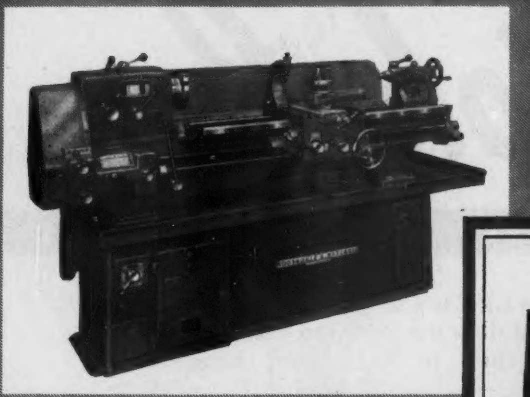

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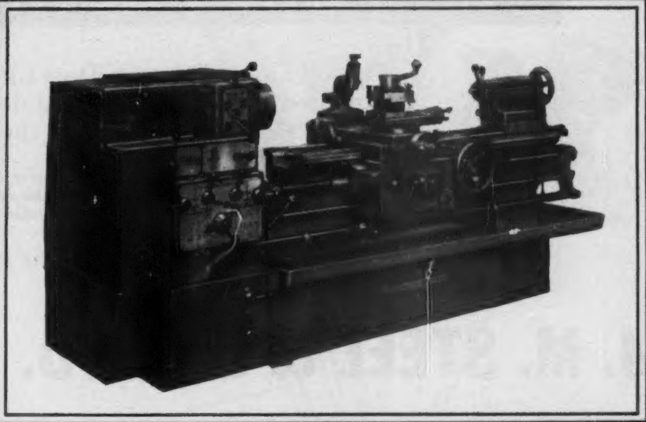

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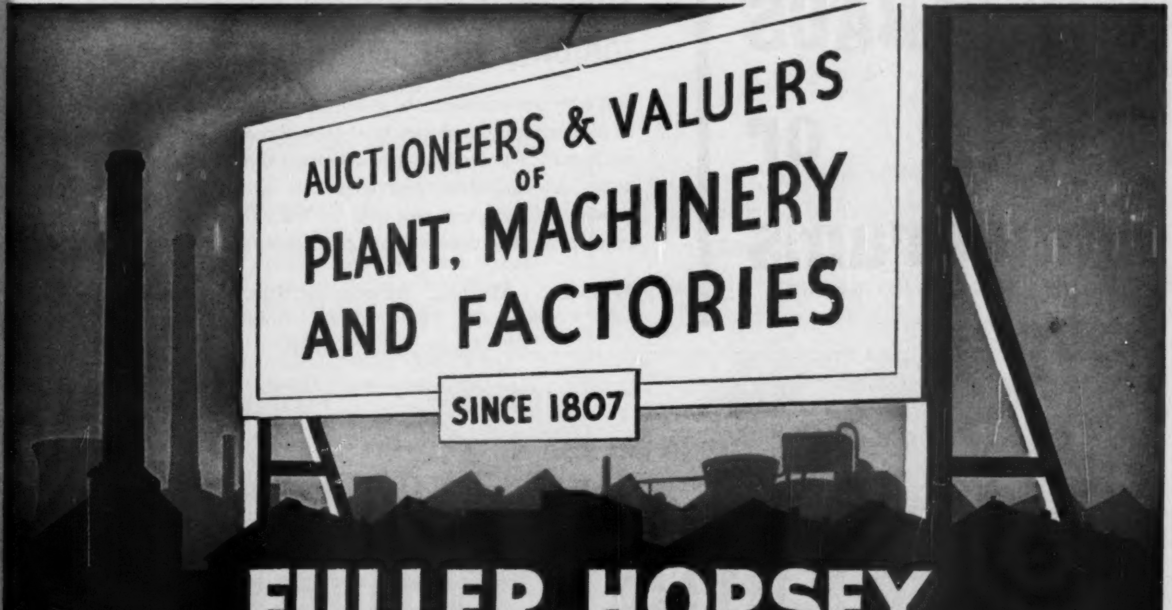

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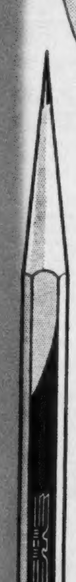

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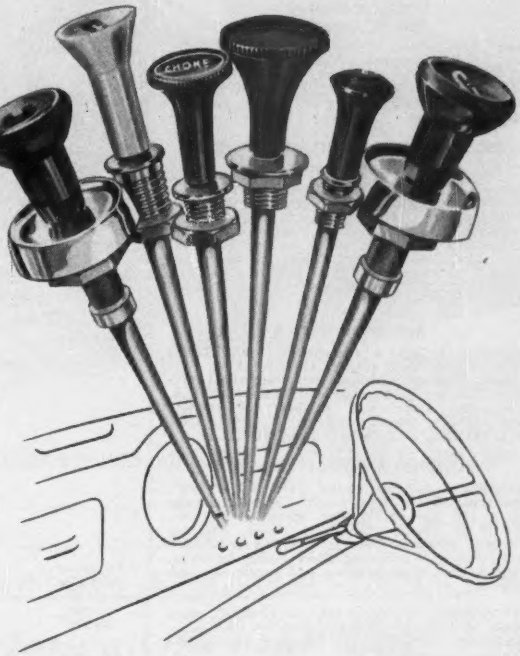

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